

Small Satellite Constellations; the future for operational Earth Observation

JACIE Workshop 14 March 2006

Paul Stephens
Marketing Director
p.stephens@dmccii.com



Pioneering a different approach to space



SSTL's nanosat



SSTL's microsat



SSTL's minisat

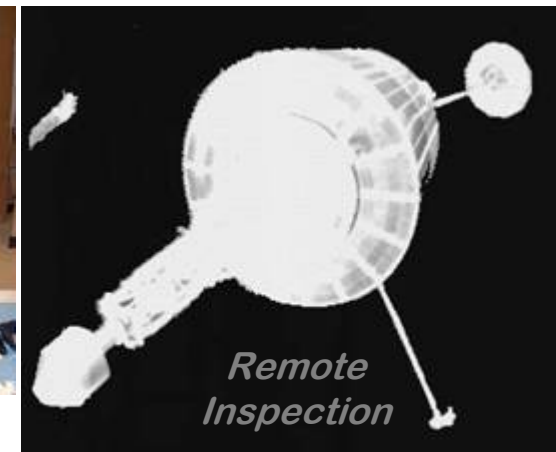
Low-cost, rapid-response small-satellites
built from advanced terrestrial technology



	<i>Mass</i>	<i>Cost</i>	<i>Time</i>	<i>Tech</i>
ESA Envisat	8000kg	\$3000m	15yrs	4MIPS
SSTL SNAP-1	6.5kg	\$1m	6 mths	10MIPS



SNAP-1 under construction



Disruptive Technology: 'PC in Space'

- Similar impact as PC in computer industry and user community

SSTL delivers the benefits of *Affordable Access to Space* through low-cost, rapid response, small satellites designed & built with state-of-the art COTS technologies.

- Reducing the cost of entry into space
- Achieving more missions within fixed budgets
- Making constellations & formation flying financially viable
- Responding rapidly from initial concept to orbital operation
- Bringing the latest industrial COTS component advances to space

SSTL has stimulated growth in two key areas:

- Constellations for high temporal revisit & persistent monitoring
- Military responsive space assets



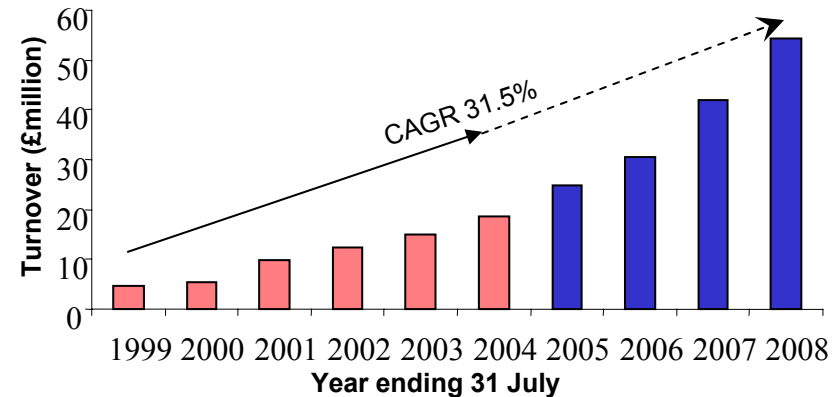
Surrey Satellite Technology Ltd is a private British satellite manufacturing company owned by the University of Surrey (80%), employees (10%) and USA Space-X (10%)

- Formed in 1985, the Company now employs >200 staff and occupies dedicated facilities at the Surrey Space Centre.



- New purpose-built building on University Research Park ready early 2006

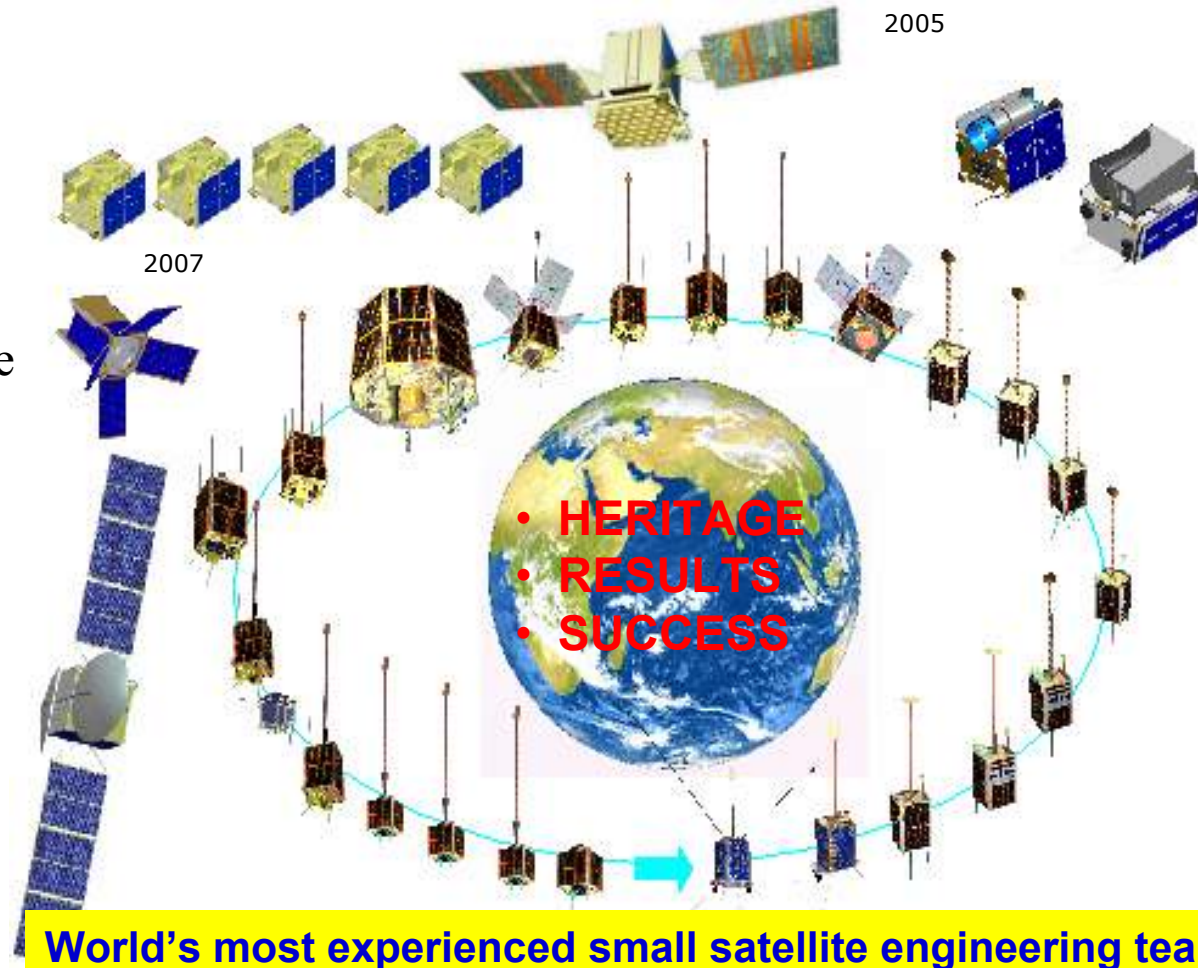
**Aiming at a decade
of 30% growth**



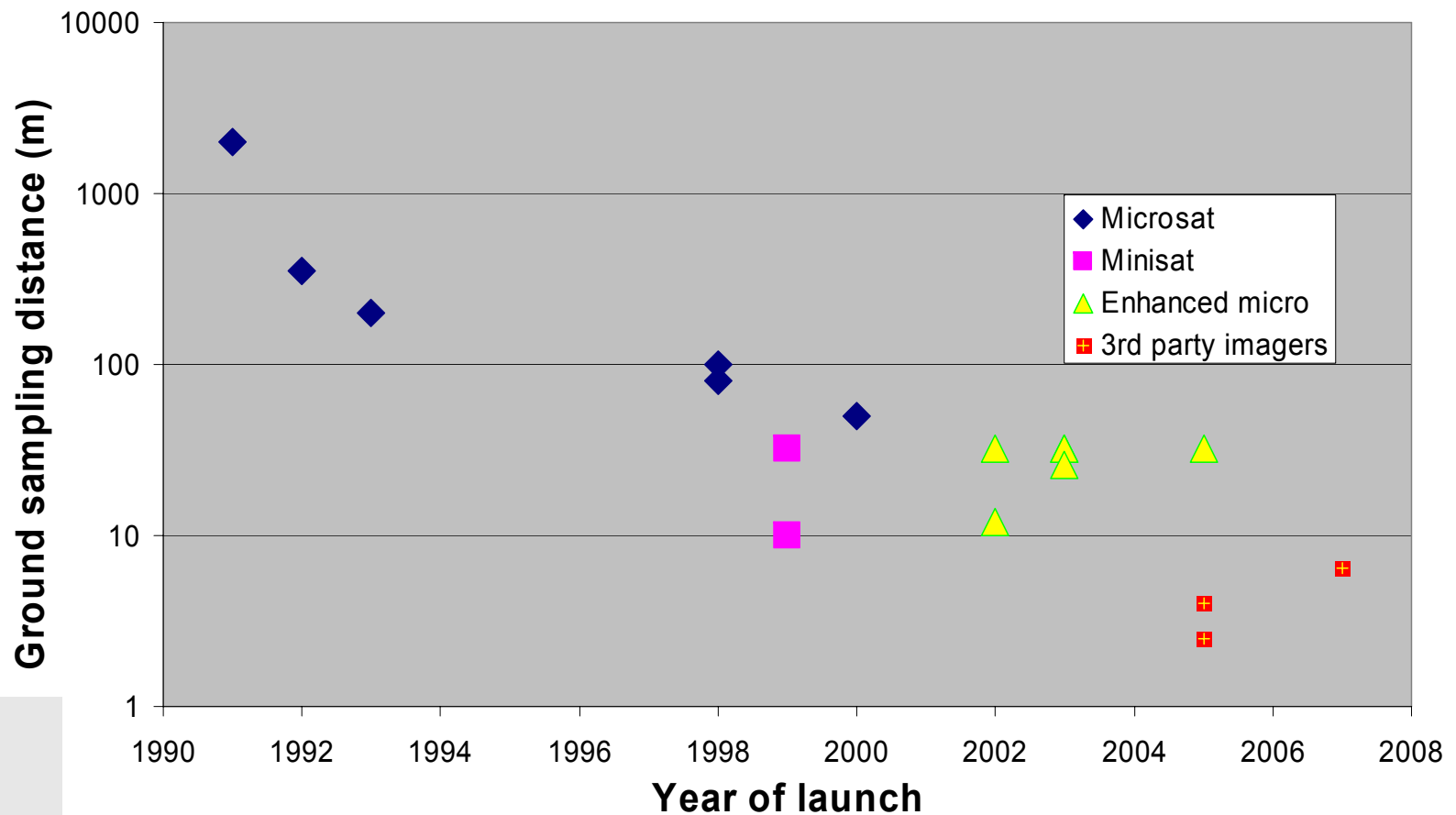
- **Space Exploration Technologies Corporation**
 - Founded in 2002 by Elon Musk
 - El Segundo, California
 - Aims at “reducing the cost and increase the reliability of access to space ultimately by a factor of ten”
 - Developing a family of launchers:
 - Falcon-1, \$6.7m, c. 500kg in LEO
 - Falcon-5, 4 ton in LEO, 1.1 ton in GTO
 - 1st Launch Early 2006
 - \$200m order book



- Entry level satellites
- High performance LEO satellites
- Geostationary & MEO minisatellites



Improvement in optical imaging resolution of SSTL low cost small satellites





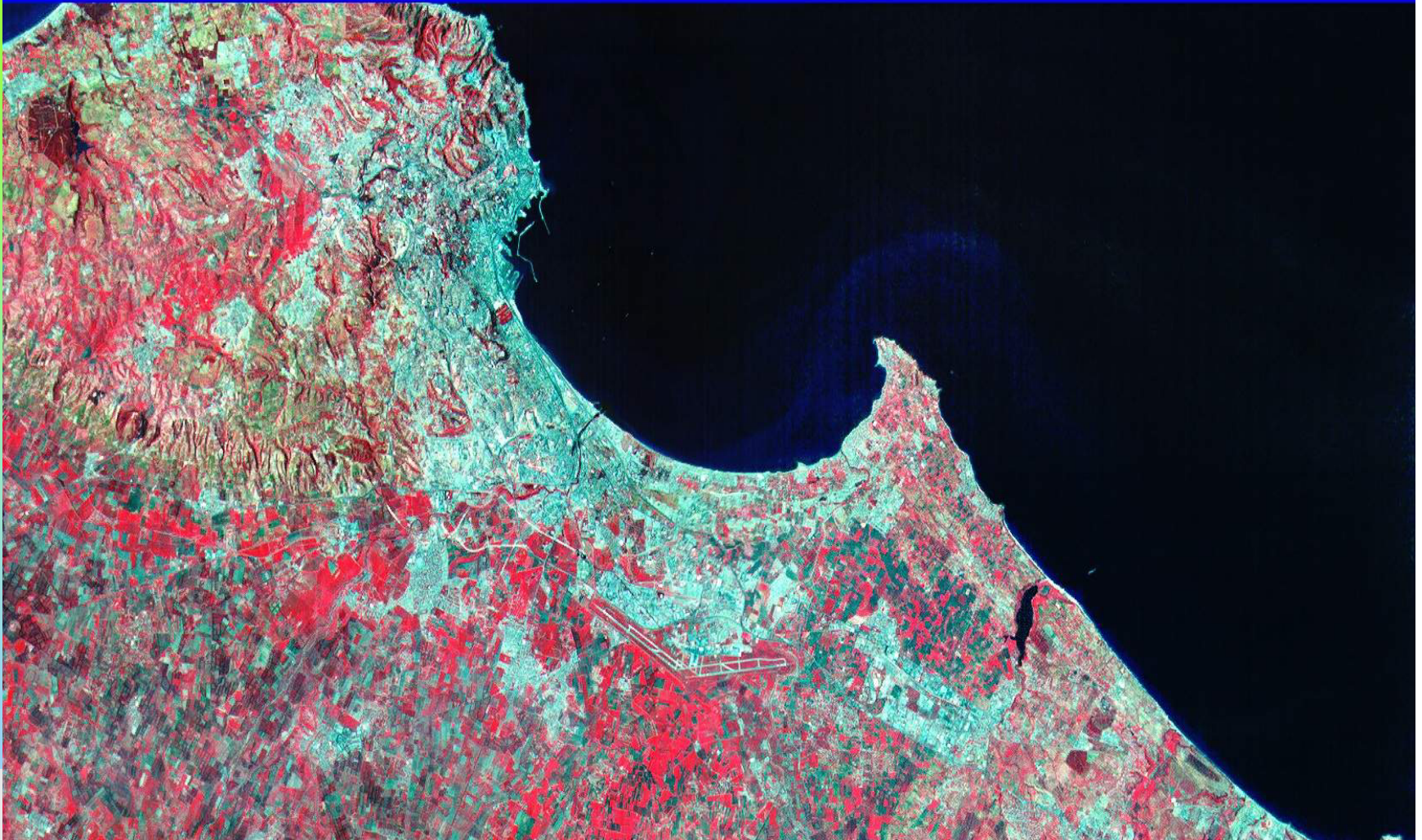
TM Sat image – Incheon, 100m multispectral





TiungSat image – Trans-Arabian pipeline, 80m multispectral





UoSAT12 image – Algiers, 32m multispectral



UoSat12 image – Algiers, 10m panchromatic





DMC+4 Cairo airport 4m panchromatic imager by SIRA

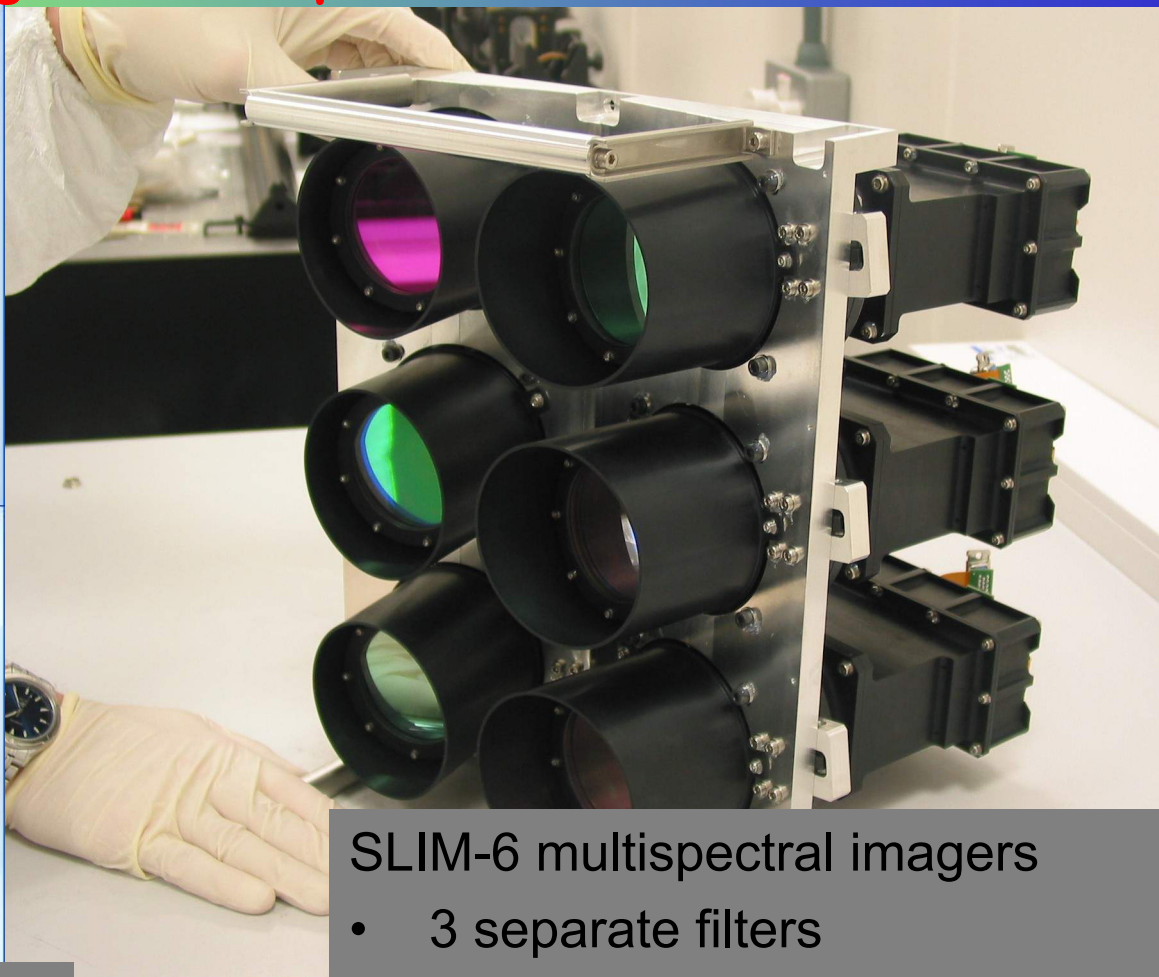
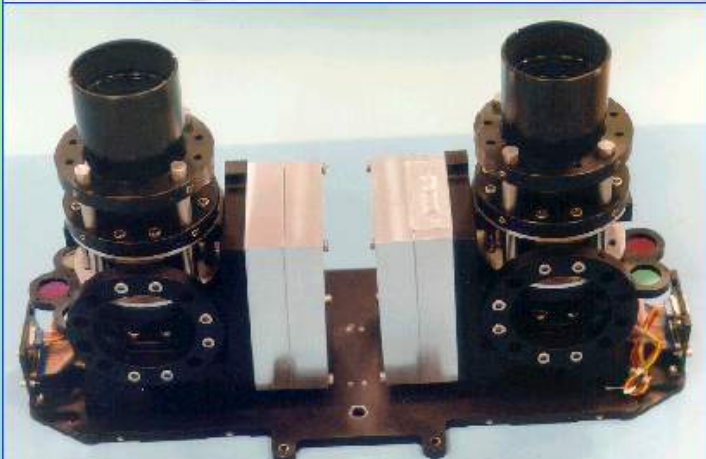




TOPSAT QE bridge 2.5m panchromatic/ 5m m/s imager by RAL



SSTL EO Cameras using COTS components



UOSat-12 multispectral imagers

- 8-filter wheel
- 32m gsd resolution
- 60 x 30km image

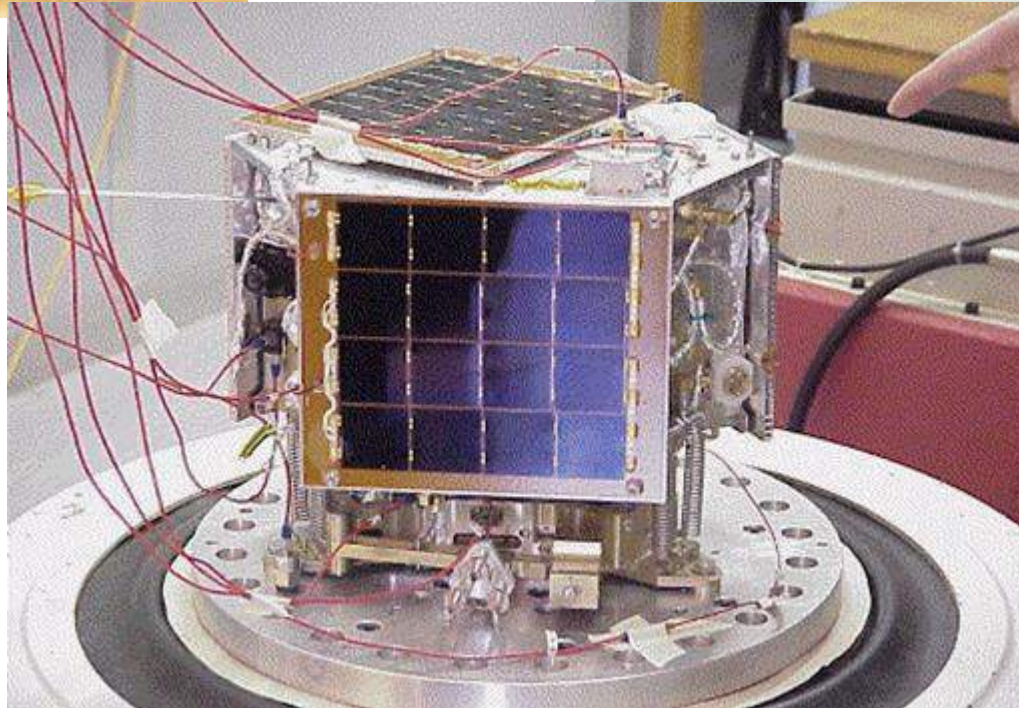
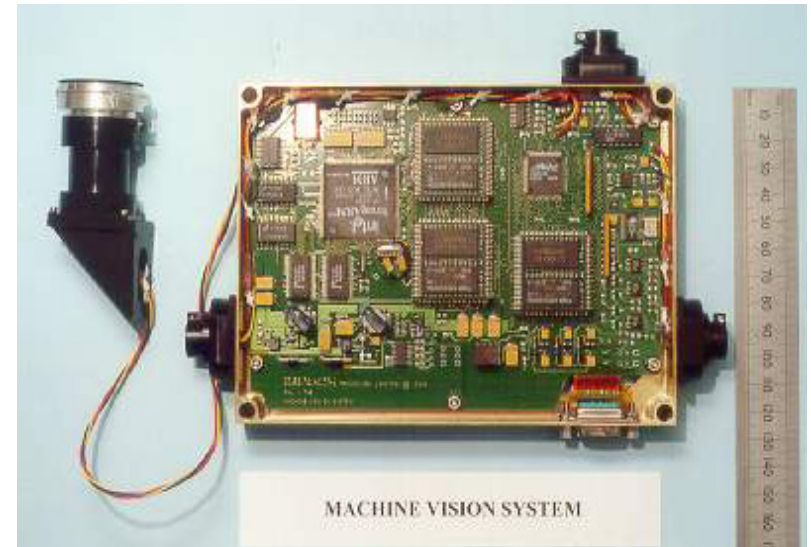
SLIM-6 multispectral imagers

- 3 separate filters
- 2 banks of imagers
- 32m gsd resolution
- 600 x 300km image
- 100 x more area

... and at the other end of the scale

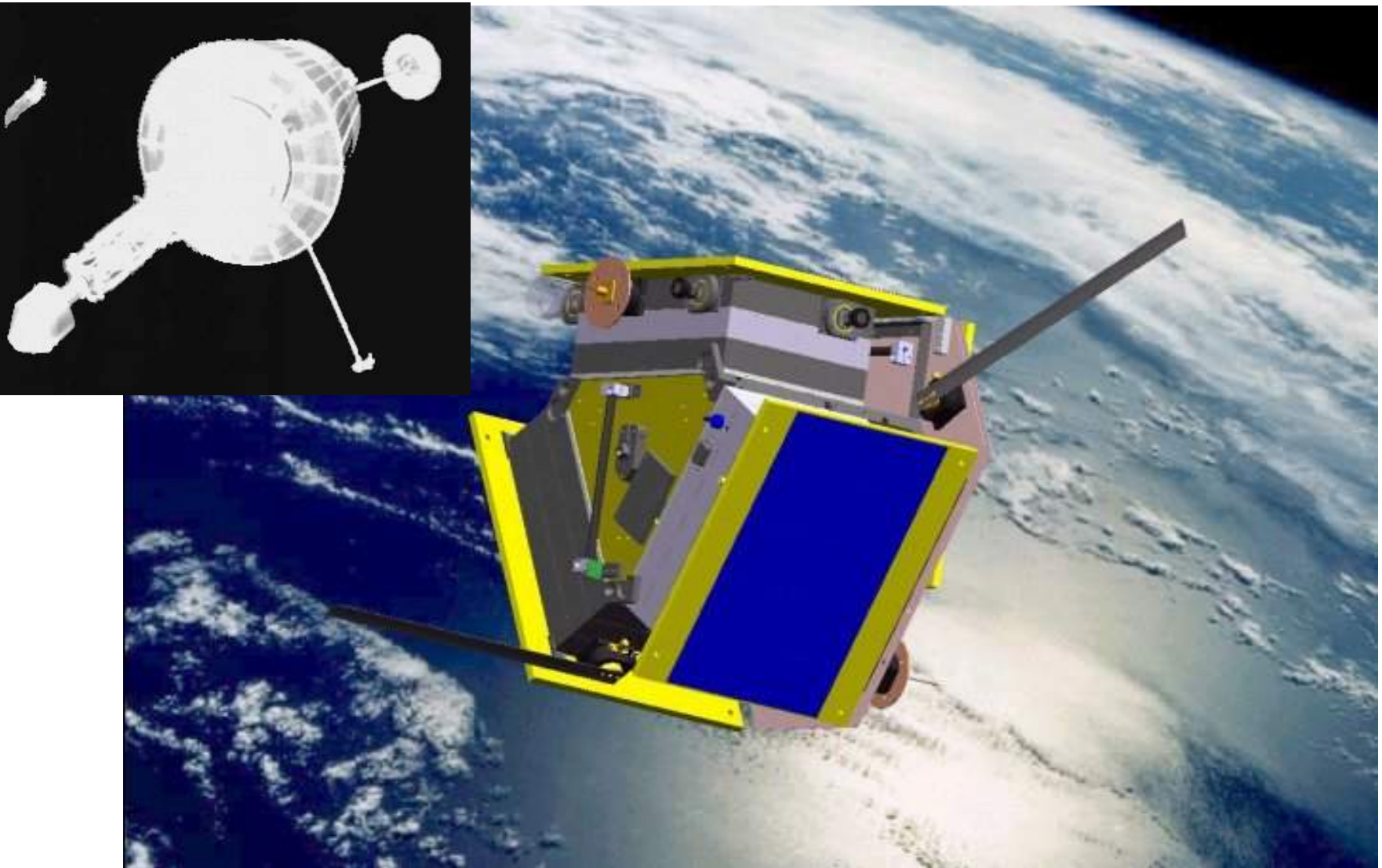


... the Nanosatellite



... the Nanosatellite (cont.)

... and at the other end of the scale

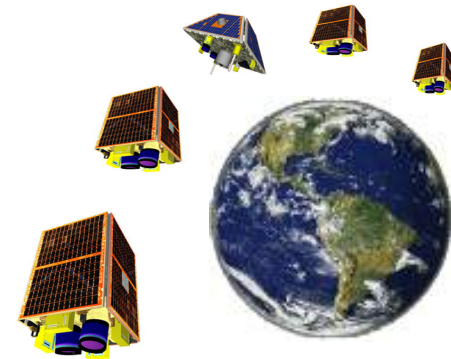


... the “LapTop” of space

A Unique International Partnership Combining National Objectives, Humanitarian Aid and Commerce...



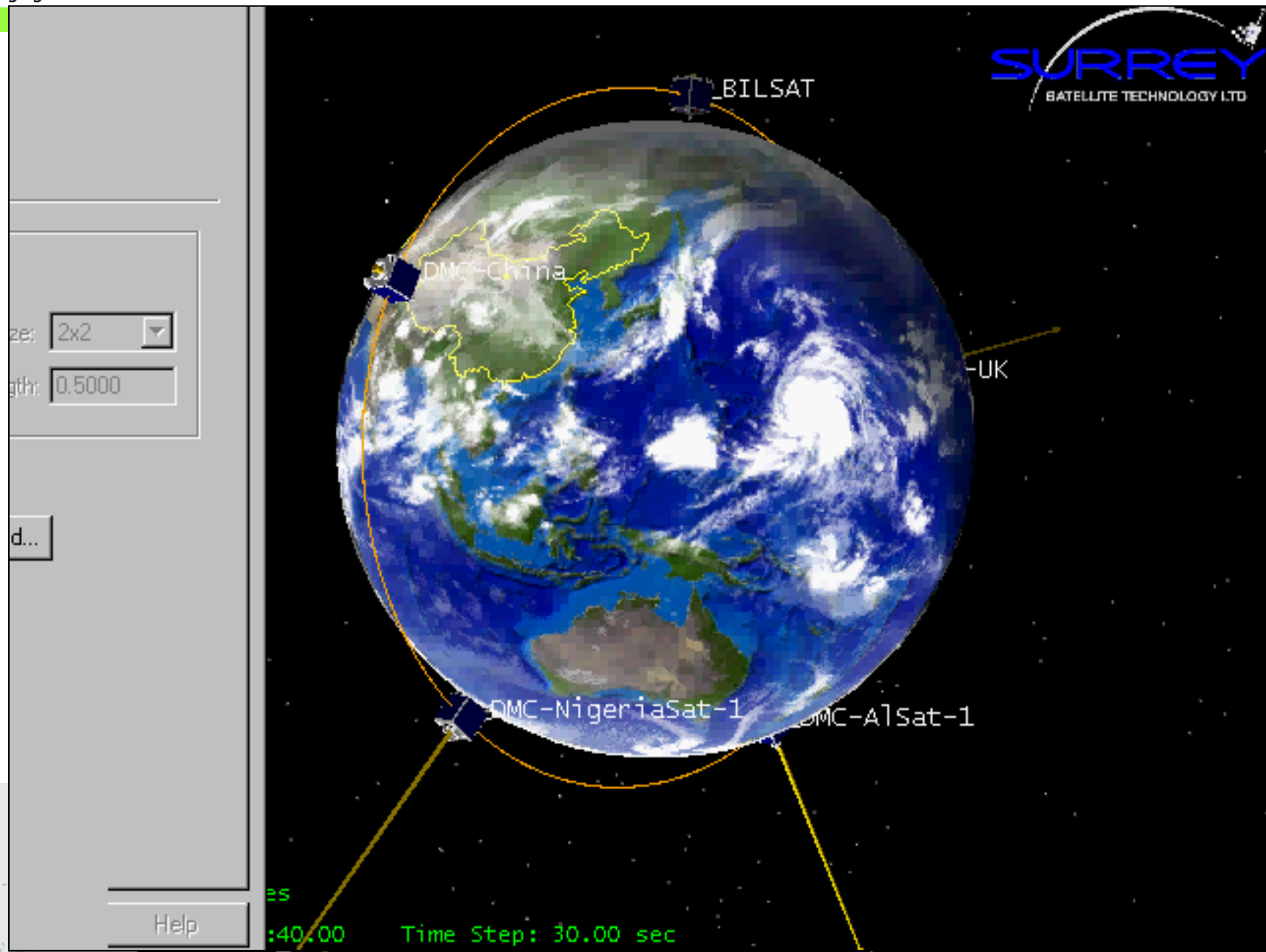
The Consortium



The Constellation

- ALSAT-1
- BEIJING-1
- NigeriaSat-1
- BILSAT
- UK-DMC



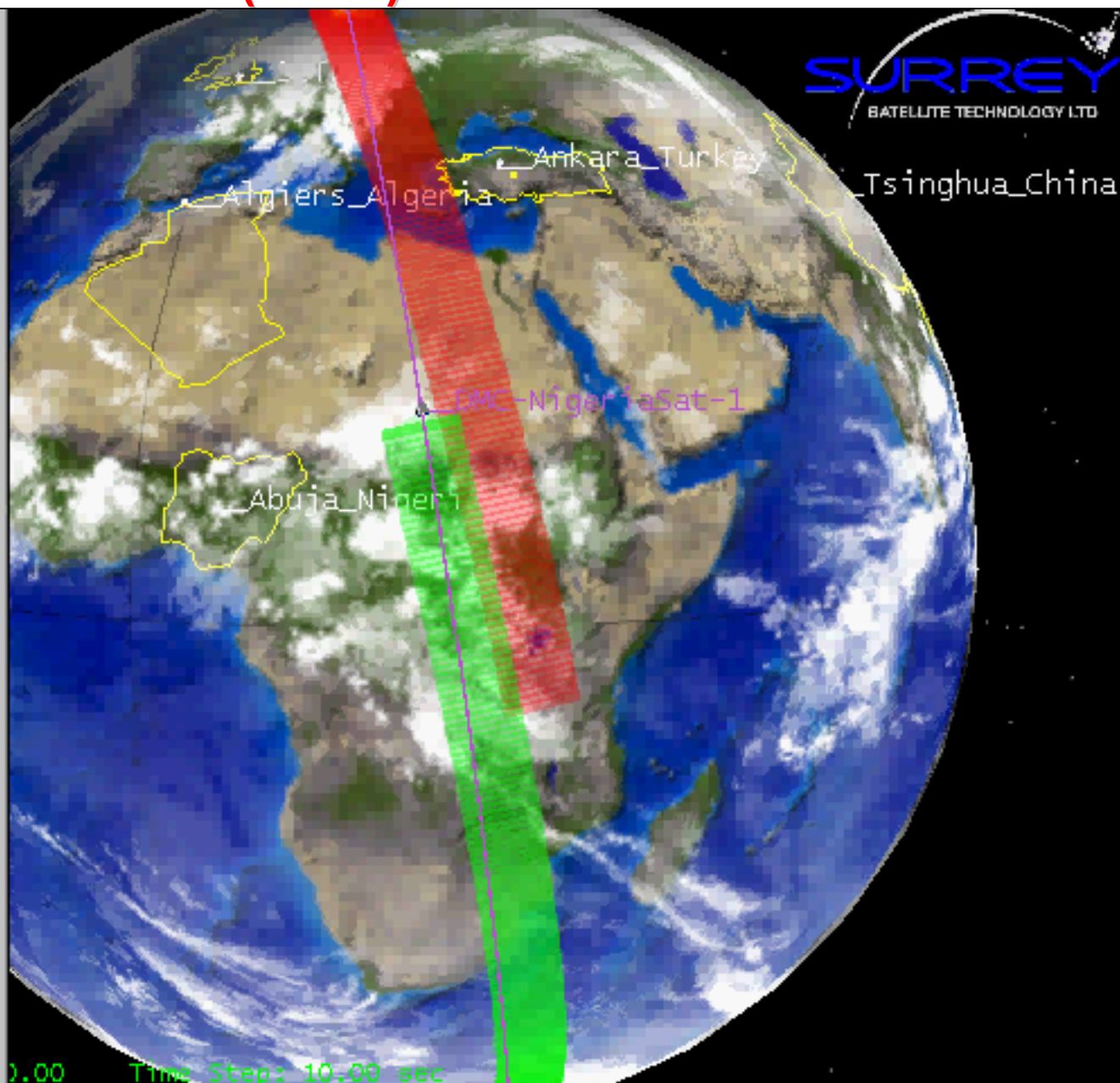


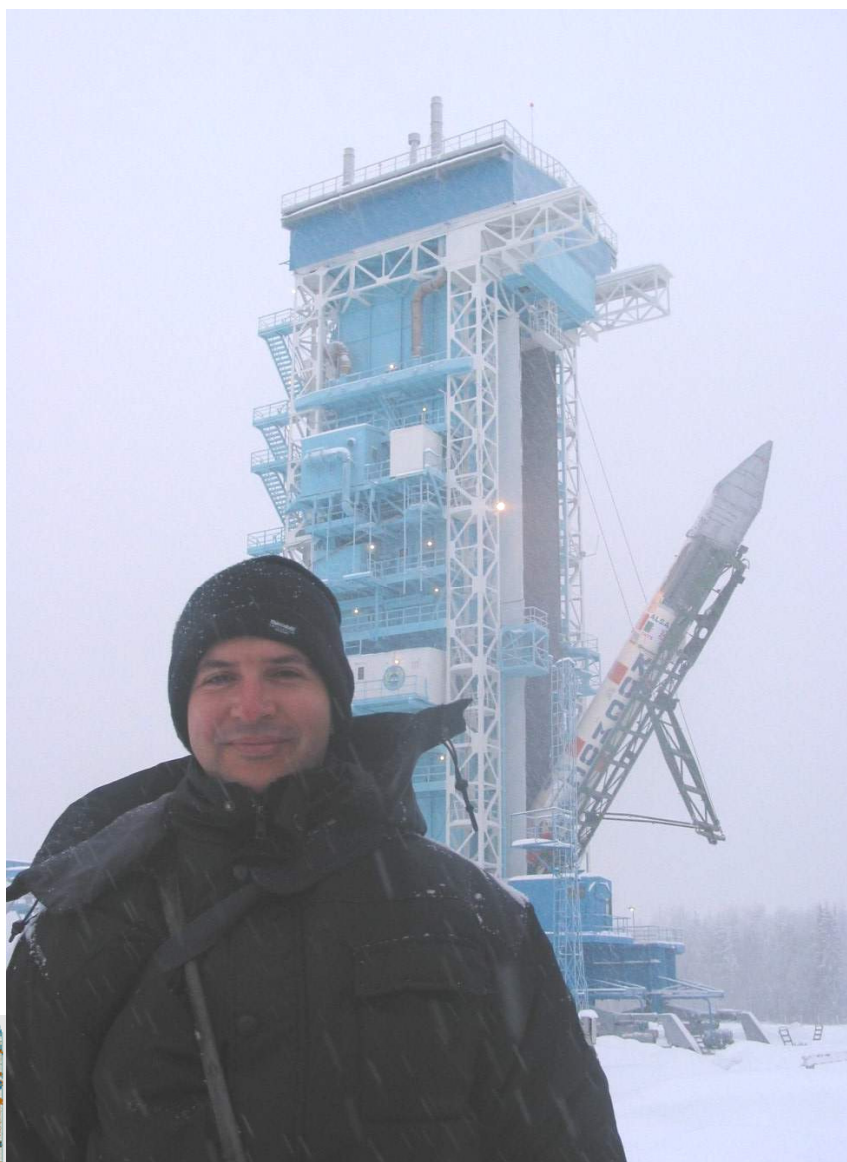
Disaster Monitoring Constellation (cont.)

Size: 2x2
Length: 0.5000

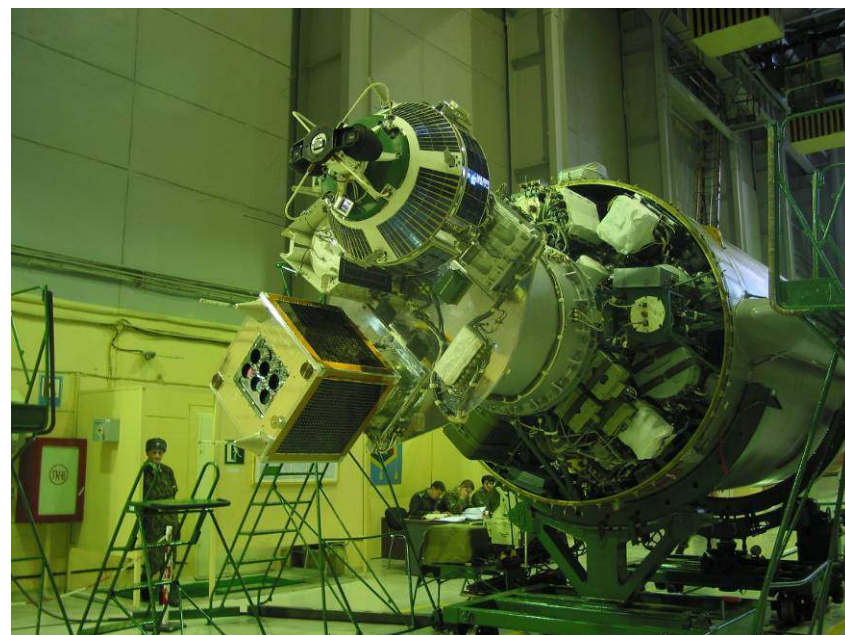
anced...

Help



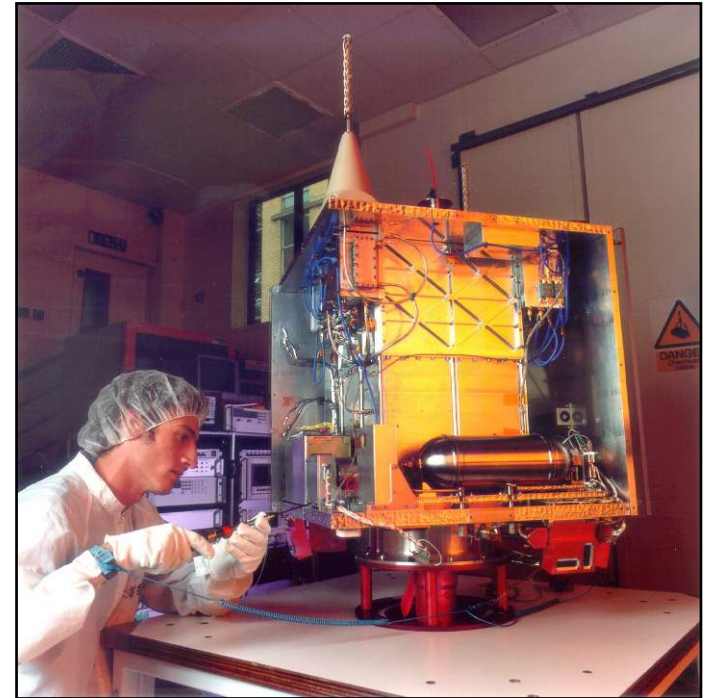
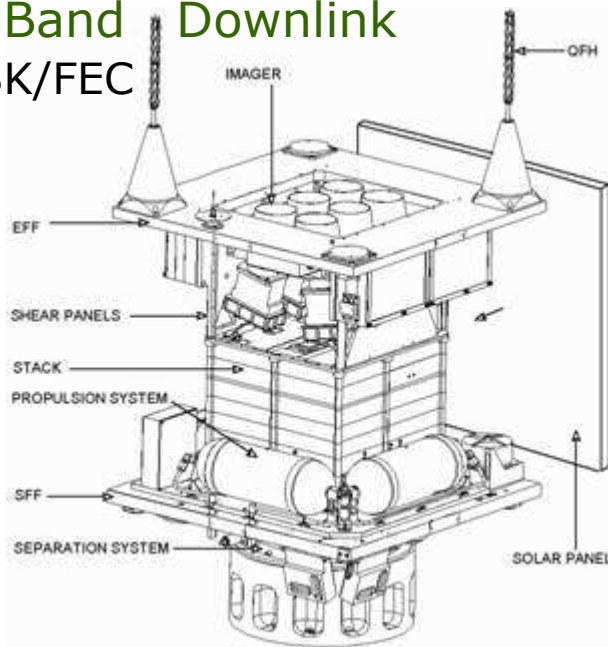


Cosmos-3M, Plesetsk Cosmodrome



Kosmos 11K65M, Plesetsk Cosmodrome

- 5 year design life
- Weight - 90 kg
- Resistojet Electro-Thermal Propulsion
 - Butane CGT
- Data Handling
 - 386 On Board Computer (OBC)
 - CAN TT&C
 - 1GB Solid State Data Recorders
 - Onboard GPS Receiver
- 8Mb S-Band Downlink
 - QPSK/FEC



- ADCS
 - $<0.01^\circ/\text{s}$, accuracy $<1.0^\circ$
- DMC SLIM6 Imager Pushbroom
 - 32m multi-spectral (3-bands)
 - 600km swath width
 - 1.5Gbytes SSDR



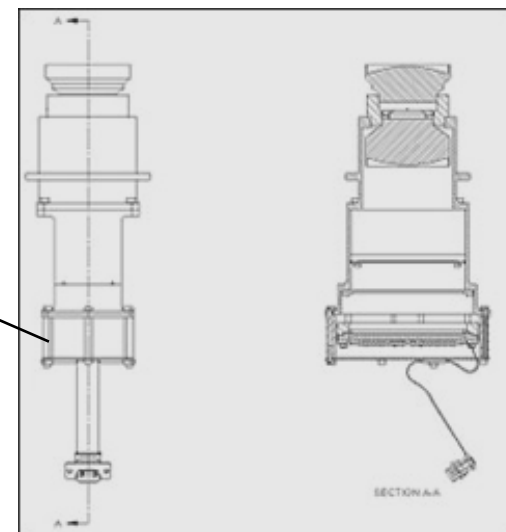
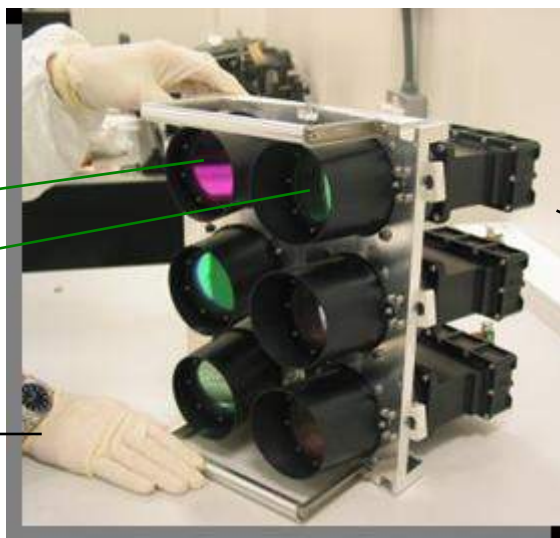
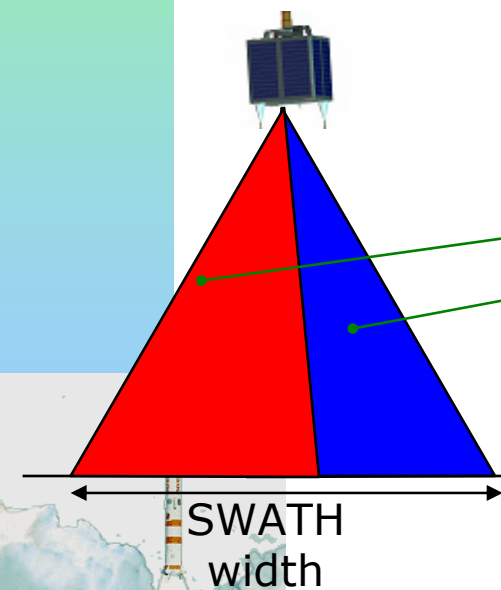
Sensor: Eastman Kodak KL10203 Linear CCD
10224 7.0 x 7.0um pixel array

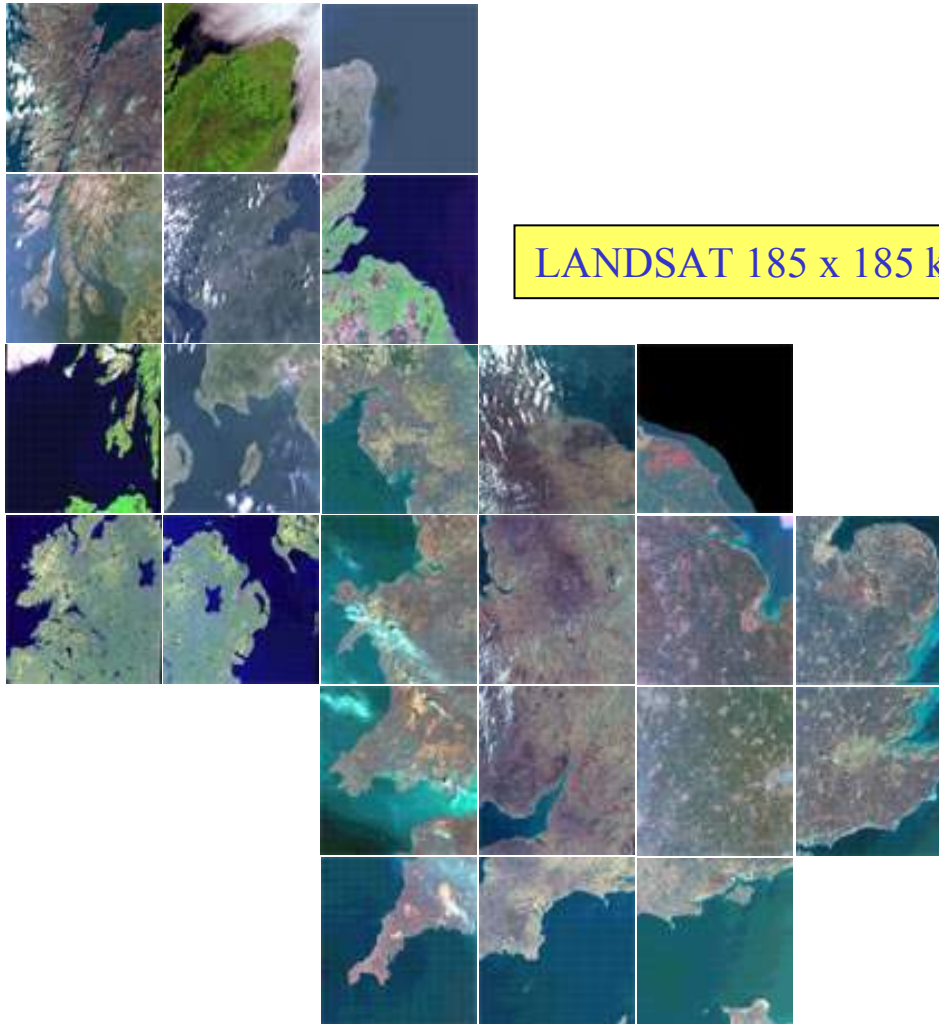
Lens: Schneider Apo-Componom HM
150mm, f/6.3

Per channel
FoV= 26.62 degrees
Swath = 324.58km

Filters: Barr Associates Inc., USA
Landsat equivalent

- NIR 0.77 - 0.90um ETM+4
- Red 0.63 - 0.69um ETM+3
- Green 0.52 - 0.60um ETM+2

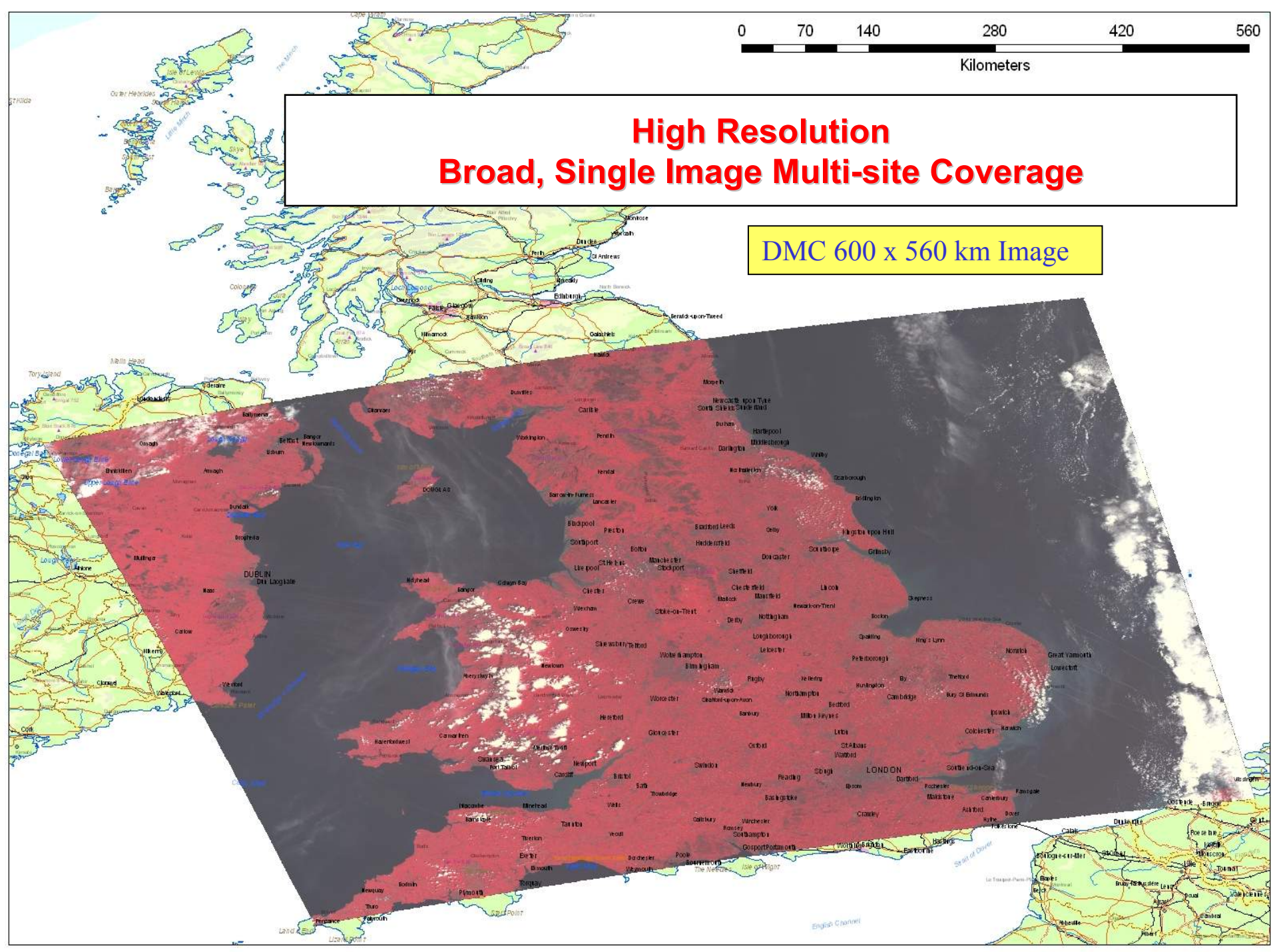




0 70 140 280 420 560
Kilometers

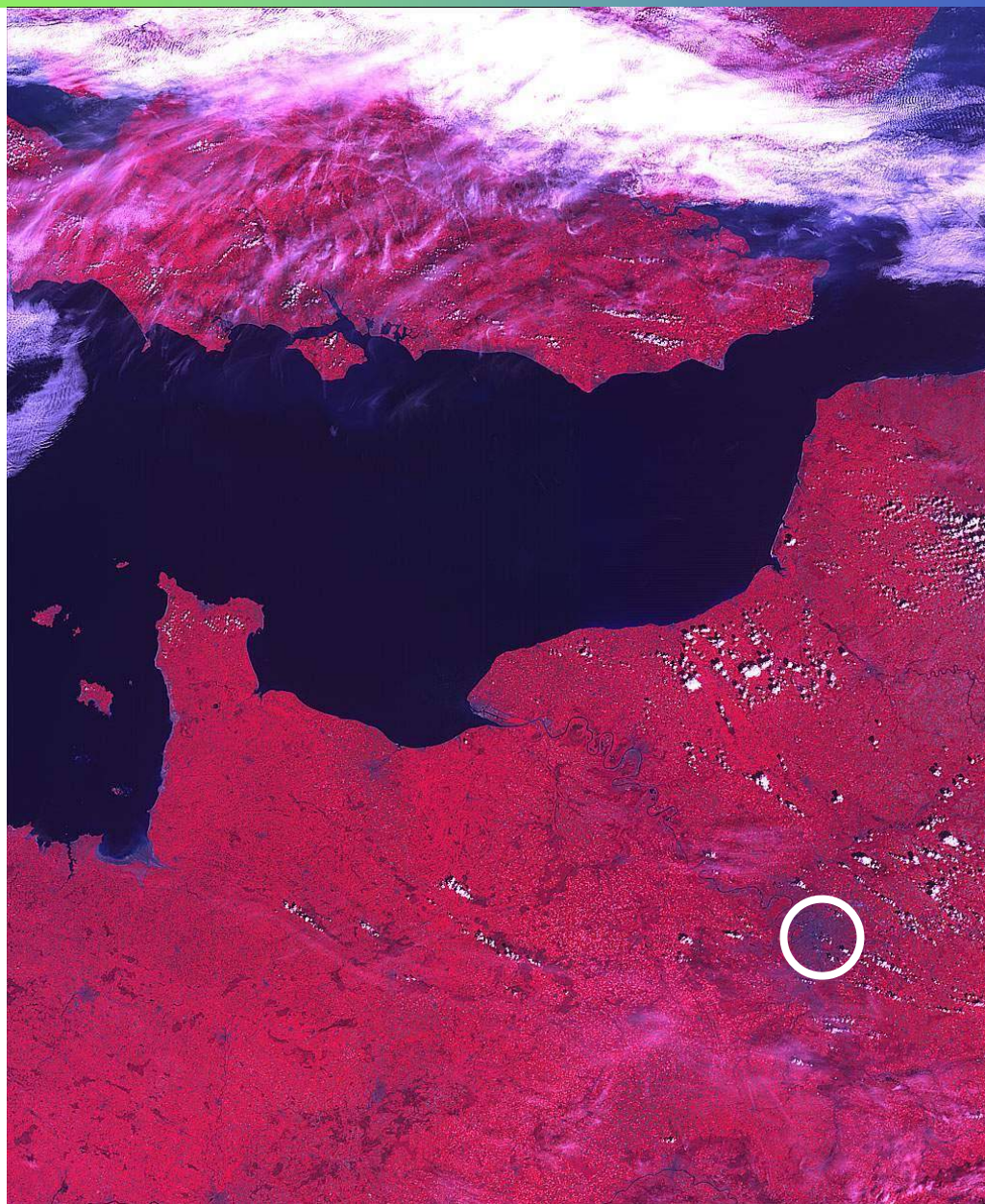
High Resolution Broad, Single Image Multi-site Coverage

DMC 600 x 560 km Image



DMC in Operation

France (32m GSD 3-band m/s)

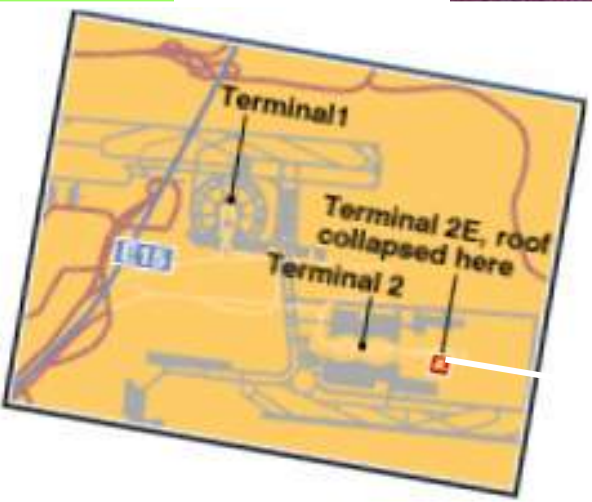


continued



DMC in Operation (cont.)

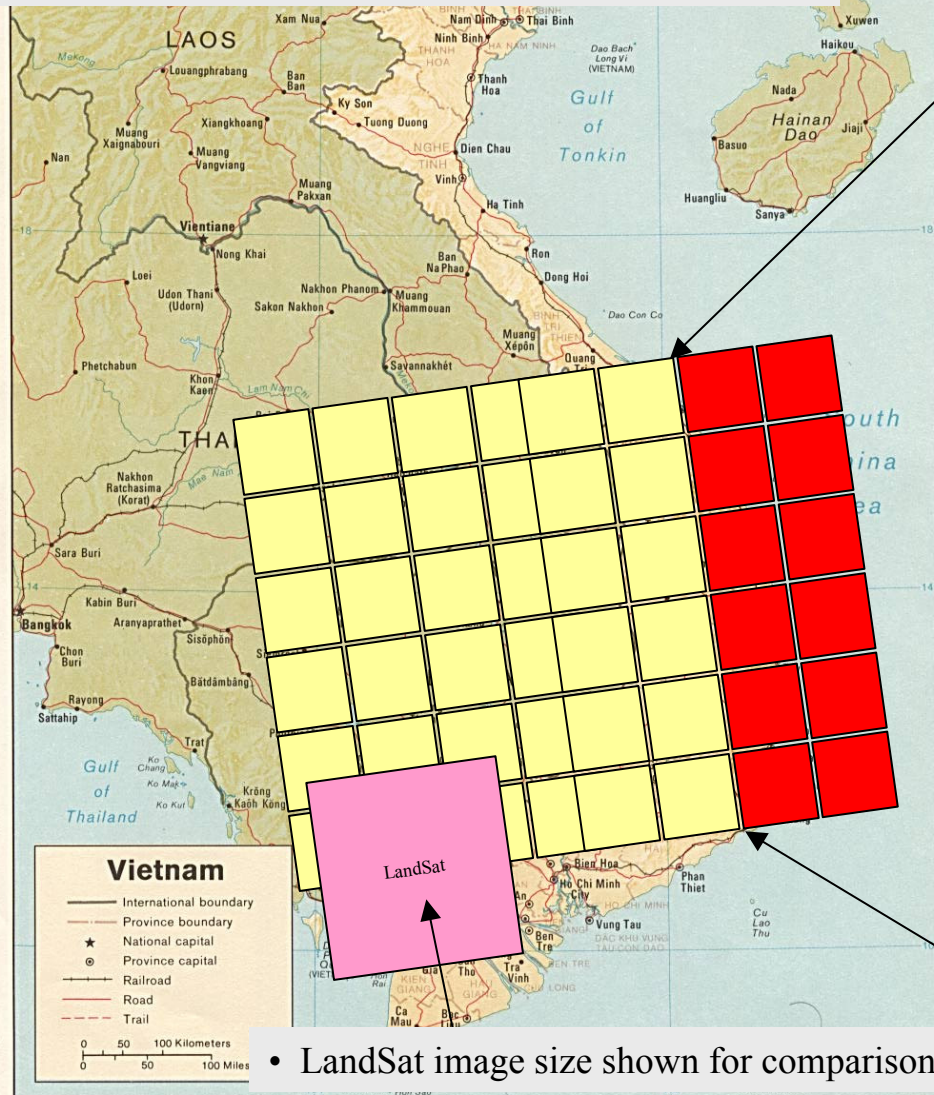
France (32m GSD 3-band m/s)



Charles de Gaulle airport, Paris



- DMC satellite 32m gsd multispectral image - maximum onboard storage is 600km swath x 570km along track. Imaging area normally 24 tiles, but can be selected to cover maximum of 48 image tiles. Each tile is 80x80km



- LandSat image size shown for comparison

Image from the first
Disaster Monitoring
Constellation satellite
ALSAT-1, 16th June 2003
built by
Surrey Satellite Technology
at Surrey Space Centre, UK
for Centre National des
Techniques Spatiales, Algeria



Commercial Supplier for DMC Imagery

Objectives

1. International Sales of DMC images
2. Manage DMC Image Quality
3. Coordinate Disaster Response



Level	Description	File Format
RAW	Raw imagery as acquired by sensor. Available upon request.	BIL
L0R	Individual band files Radiometrically corrected	TIFF
L1R	Registered bands Radiometrically corrected.	TIFF
L1G	As L1R plus: Geometric correction of systematic effects Standard cartographic projection (UTM WGS84 default)	GeoTIFF
L1T	As L1G plus: Orthorectified (1 km DEM) Higher resolution DEMs were available	GeoTIFF



FTP or DVD/CD Delivery

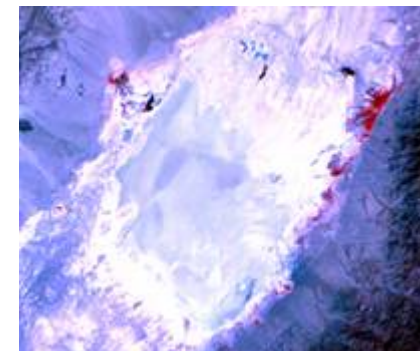


Principal Scientist Dr Stephen Mackin (Surrey Space Centre, UK)

- Annual Absolute Calibration since July 2004
 - Railroad Valley, Nevada instrumented test site
 - Facilities & TOA radiance supplied by Arizona Uni., USA
- Ongoing Monthly Relative Calibration
 - ‘Pacific at Night’ & ‘Antarctic & Greenland’ images
- No significant performance change noted
- Full documentation available
 - Calibration report
- Finalising Aug 2005 Calibration Coefficients

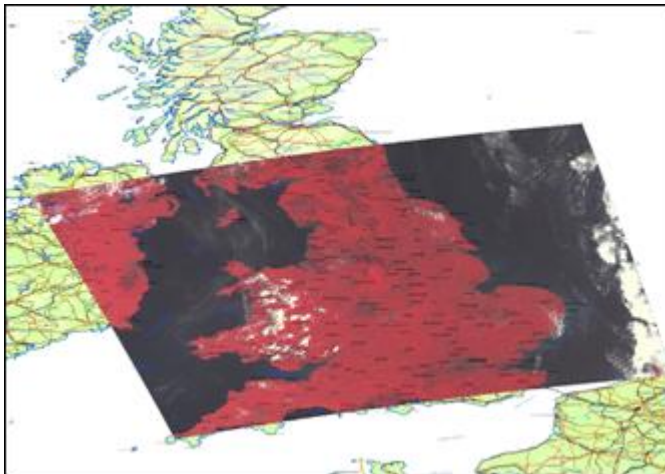


“In general this is good data. visible vertical striping...pushbroom sensor...even/odd detector bias... easily correctable in processing...no other radiometric problems in the data.” **USGS**



- Automated Orthorectification (Spacemetric Keystone)
 - Automatic GCP Extraction from Landsat GLC Orthos
- Precision Manual Orthorectification Service
 - Sub pixel accuracy (Better than 25m RMS)
 - Standard Global reference: Landsat Geocover, GLOBE DEM
 - High precision local data sets utilised where available

Demanding customer routinely achieves 1/2 pixel registration with high precision DEM and local GCPs using simple 2nd order polynomial on L1R data.

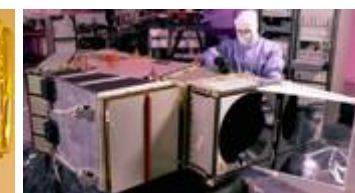


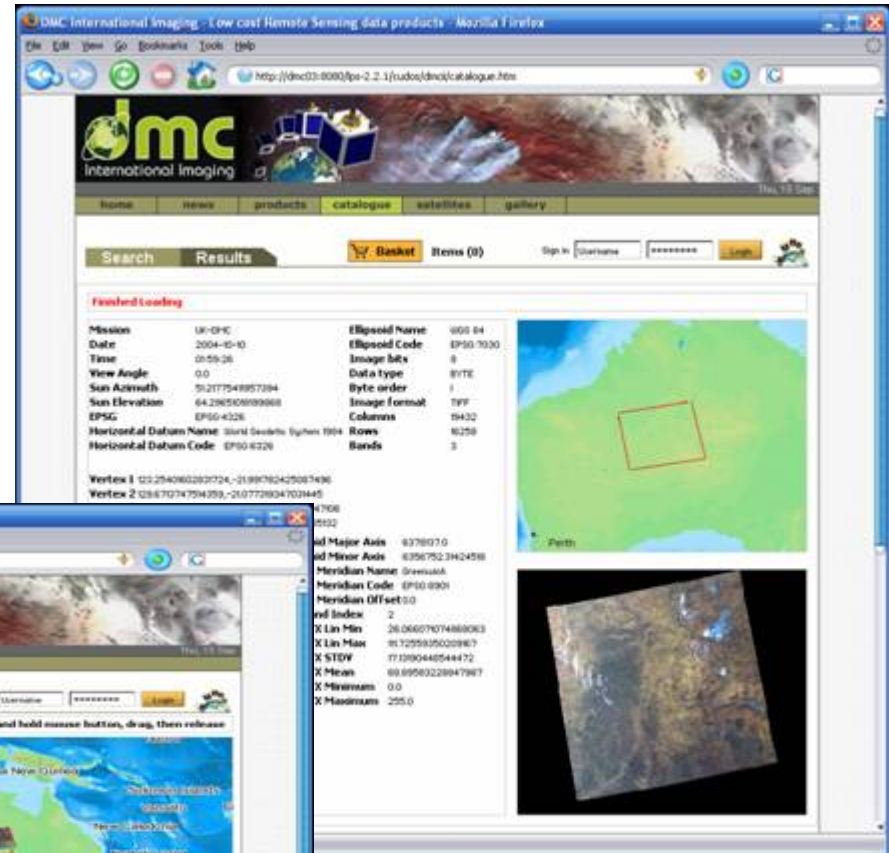
Collins Bartholomew World Regular



ESRI 1:1,000,000 World

	<i>DMC SLIM6</i>	<i>Landsat ETM+</i>
Noise	<1DN (1 SD)	<1DN (1 SD)
Signal-To-Noise	>100:1	>100:1
Absolute Radiometry	<10%	<10%
Gain	Fixed Gain (Aug-2005)	Earth Surface Dependant Gain
Integration Time	Variable	Fixed
Swath	640km (20000 Pixels)	182.61km (6087 pixels)
Quantisation	8bit (From 11)	8bit
Band: Near IR	0.77 - 0.90 μm	0.77 - 0.90 μm
Band: Red	0.63 - 0.69 μm	0.63 - 0.69 μm
Band: Green	0.52 - 0.60 μm	0.52 - 0.60 μm





**Online Archive
Search Coming
Soon**

Agriculture

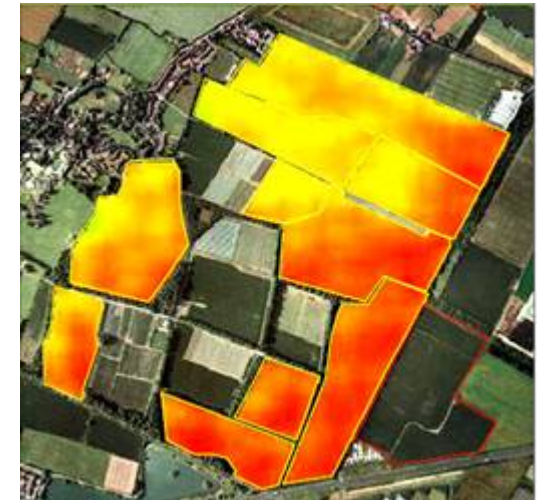
- *International Precision Farming*
- *Illicit Crop Monitoring*
- *EC AGRIFISH*
- *Food Security*



Source: ALSAT-1

Environment & Forestry

- *Coastal Erosion Monitoring*
- *Burn Scar Mapping*
- *Forest Powerline Risk Mapping*
- *Landcover & Habitat Mapping*
- *Hydrological Mapping*
- *Logging & Deforestation Management*



Brazilian Space Agency (INPE), Brazil

GTZ – COMIFAC

UNHCR

GTZ – PGDRN

Country Fire Service, Adelaide, Australia

Global Forest Watch (GFW)

US Geological Survey

Geosys SA, France

Canadian Forestry Service , Canada

WWF – Cameroon

Centre National des Techniques Spatiales, Algeria

Remote Sensing Solutions GmbH, Germany

DSTL - UK

CIC Mining Resources Ltd., China

Countryside Council of Wales, UK

AFC Consultants International GmbH

UNODC

EC Joint Research Centre

EC GSE Northern View

Seazone, UK

Vattenfall AB, Sweden

ENGESAT, Brazil

EC GSE Global Monitoring for Food Security (GMFS)

NASRDA, Nigeria

Metria, Sweden

MINFOF (Ministère des Forêts et de la Faune)

Coopération Française (through PFBC)

Agriculture – VAR Services

Online Agricultural services Including Field level monitoring of crop health...



DMC 32m data located over 5m aerial photo in UK

Environment - Illicit Crop Monitoring

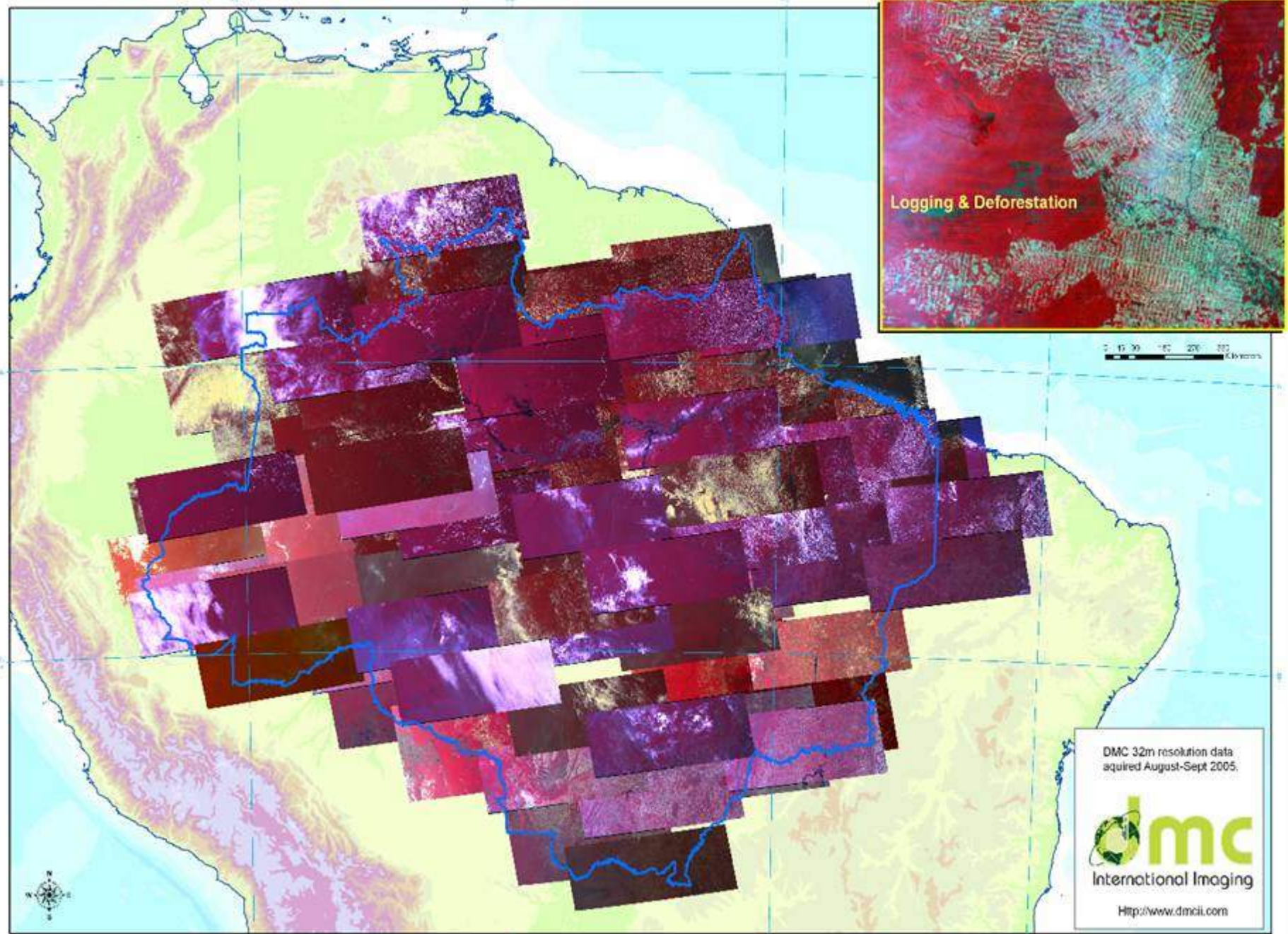
Customer: UN Office on Drugs and Crime – Spring 2005

Broad area crop mapping & classification

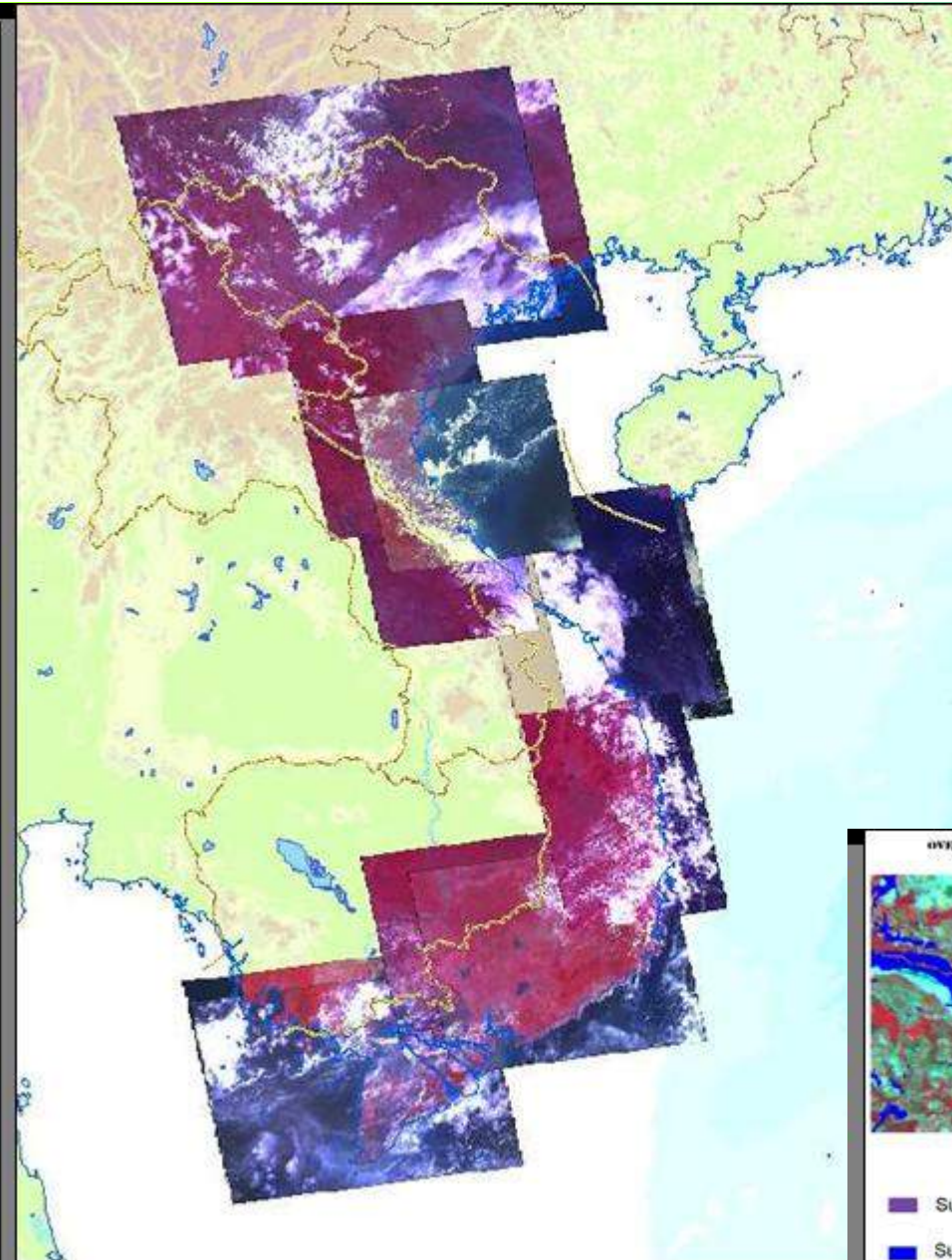
Customer: The Brazilian National Institute for Space Research (INPE) – Aug/Sep 2005



DMCII has imaged the whole Amazon basin providing the data for annual forest monitoring.
Wide area, Rapid coverage reduces cloud risk.



Amazon Basin - Brazil



DISTRICTS	COUNT	SUM AREA
DONK KUN	813	1142.37
SONHUA	807	240.45
SONG KHU	180	1188.91
SONG NHU	287	874.38
TUY AN	282	1170.38
TUY HOA	488	838.38
TUY HOA TOWN	87	480.38
Total		12246.81

Da Rang river basin,
Phu Yen province
Estimated 12,246
ha floods

DISTRICTS	COUNT	SUM AREA
HA TI	324	362.82
HAU PHO	248	888.81
BAH LO	84	733.32
HAU LU	118	675.48
HAU LUO	188	847.32
HAU LU	1	1.08
SON THAI	108	143.11
TUNG HOA	30	145.11
TUNG HOA TOWN	188	248.41
Total		25463.81

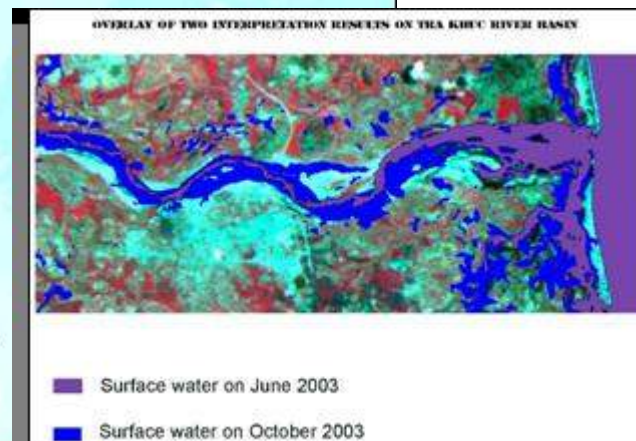
Tra Khuc river basin,
Quang Ngai province
25,463 ha floods

DISTRICTS	COUNT	SUM AREA
HAU HO	324	143.32
HAU LU	118	675.48
HAU LUO	188	847.32
HAU LU	1	1.08
SON THAI	108	143.11
TUNG HOA	30	145.11
TUNG HOA TOWN	188	248.41
Total		25463.81

Con river basin,
Dinh Binh province
25,422 ha floods

DISTRICTS	COUNT	SUM AREA
HAU HO	324	143.32
HAU LU	118	675.48
HAU LUO	188	847.32
HAU LU	1	1.08
SON THAI	108	143.11
TUNG HOA	30	145.11
TUNG HOA TOWN	188	248.41
Total		25463.81

Thu Bon river basin,
Quang Nam, Da Nang
province
13,824 ha floods



Flood analysis
with DMC data
by VAST and
MOST

Forestry - ESA EOMD: MONITOR

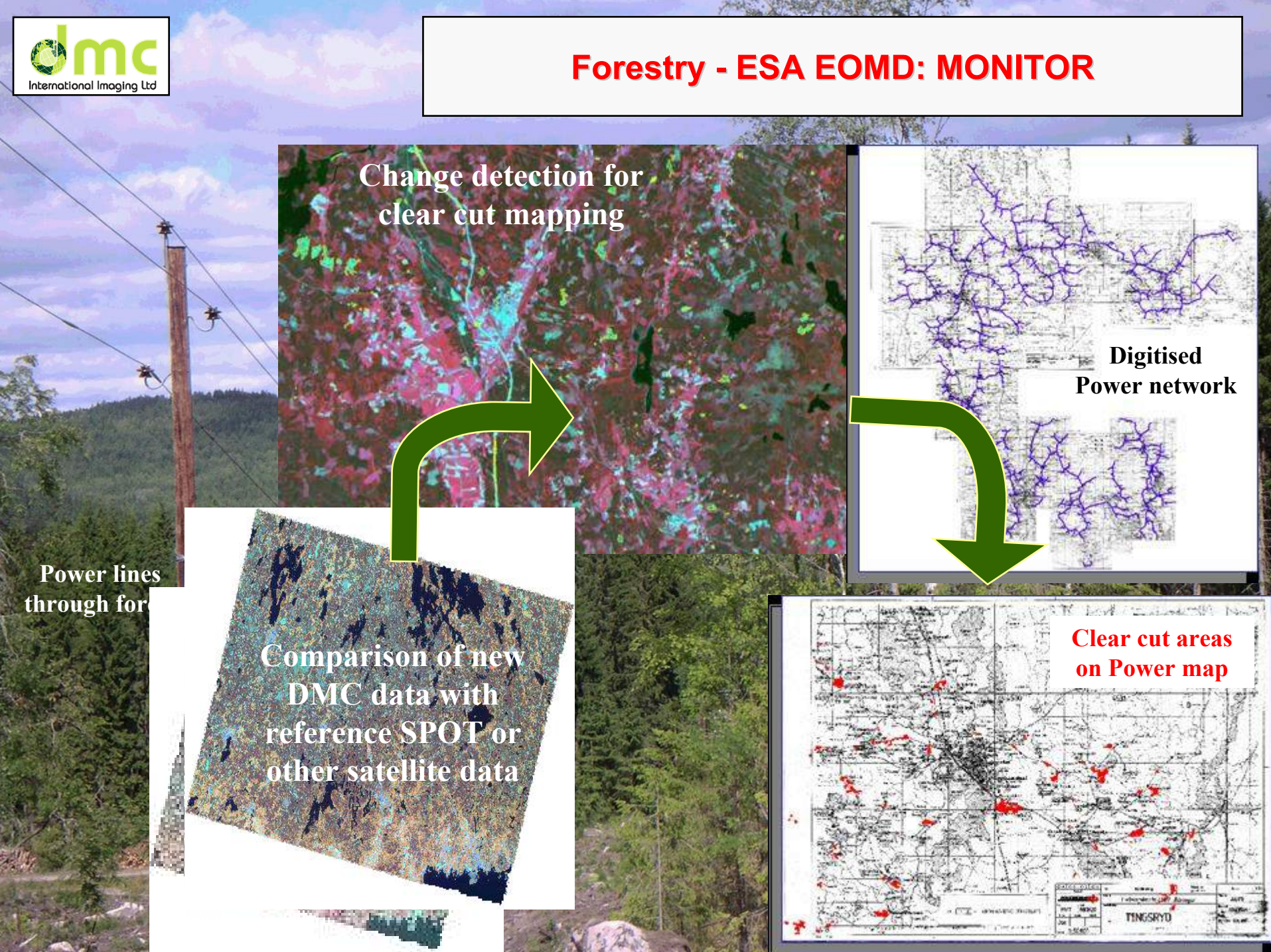
Change detection for
clear cut mapping

Digitised
Power network

Power lines
through for

Comparison of new
DMC data with
reference SPOT or
other satellite data

Clear cut areas
on Power map



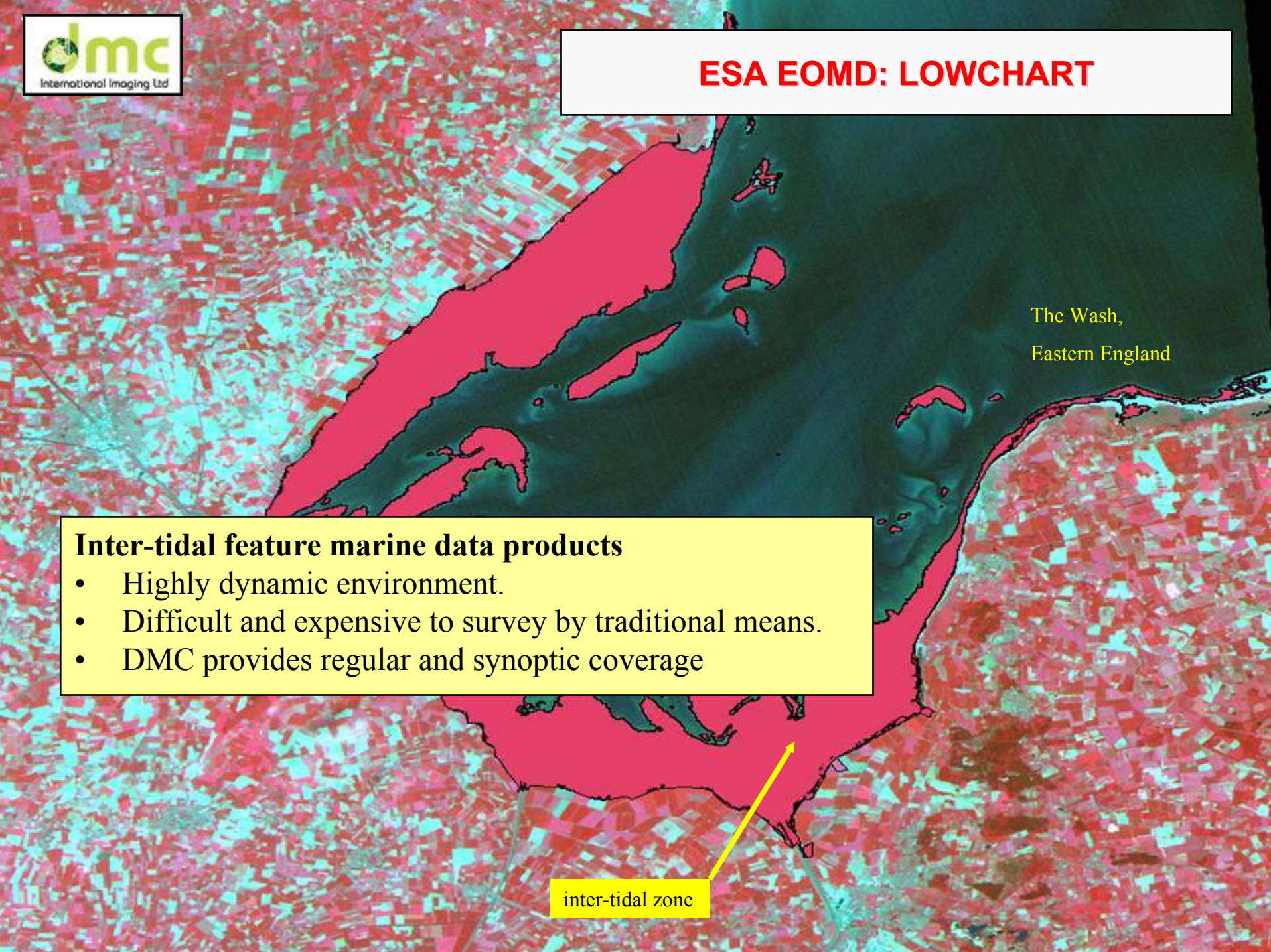
ESA EOMD: LOWCHART

The Wash,
Eastern England

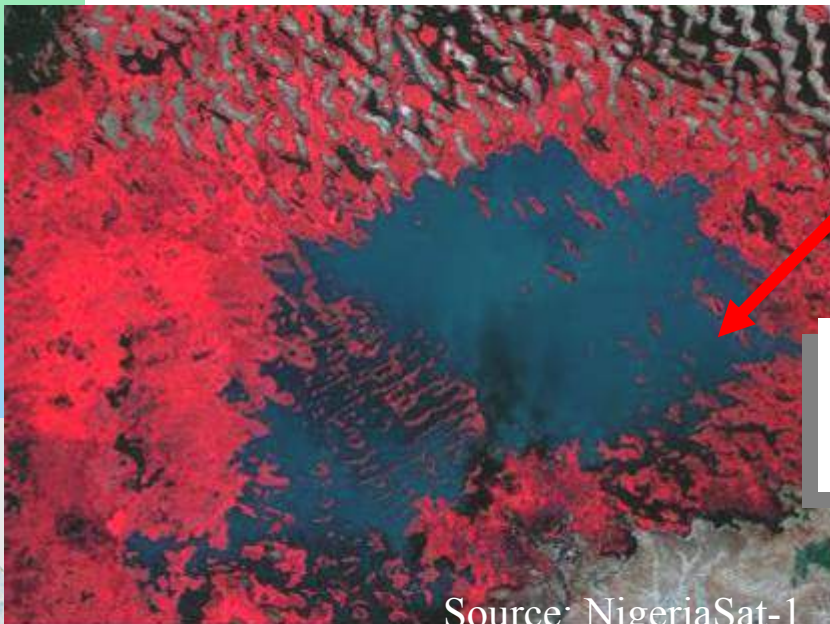
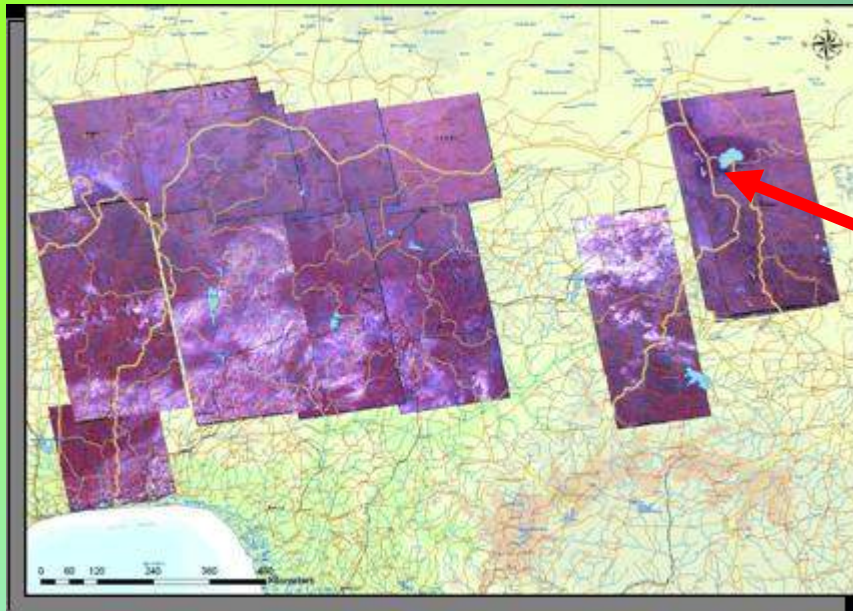
Inter-tidal feature marine data products

- Highly dynamic environment.
- Difficult and expensive to survey by traditional means.
- DMC provides regular and synoptic coverage

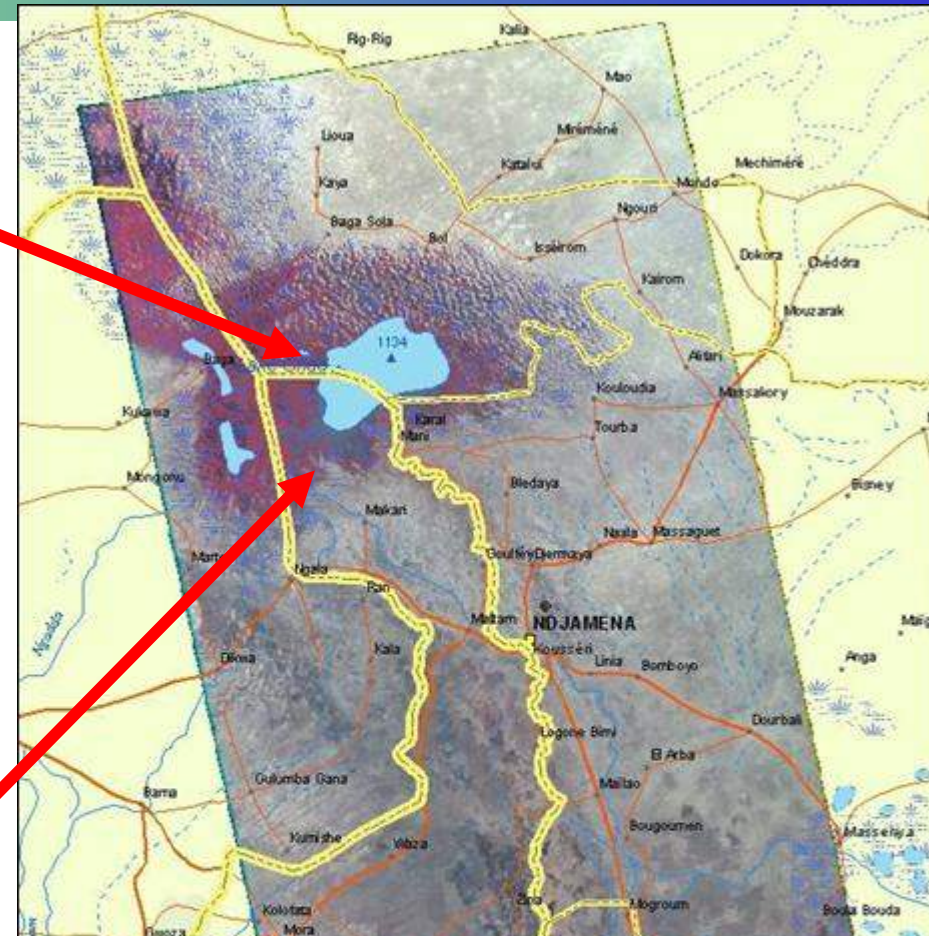
inter-tidal zone



Trans-Boundary Hydrological Mapping: Lake Chad Water Courses

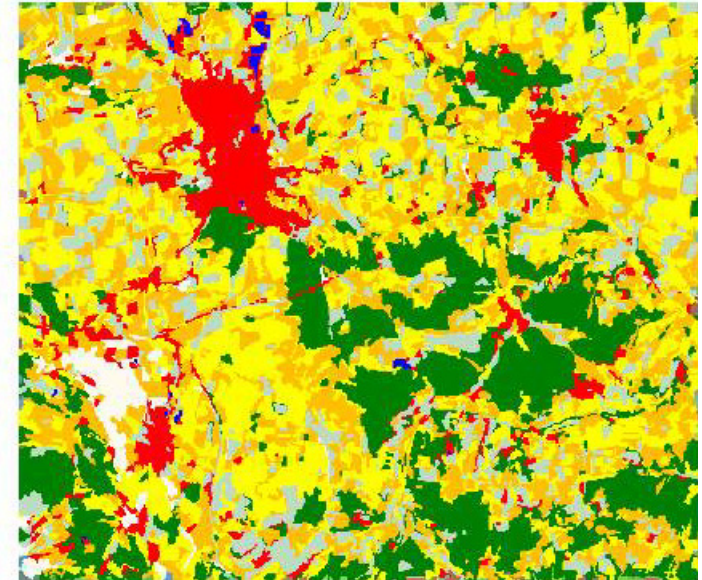
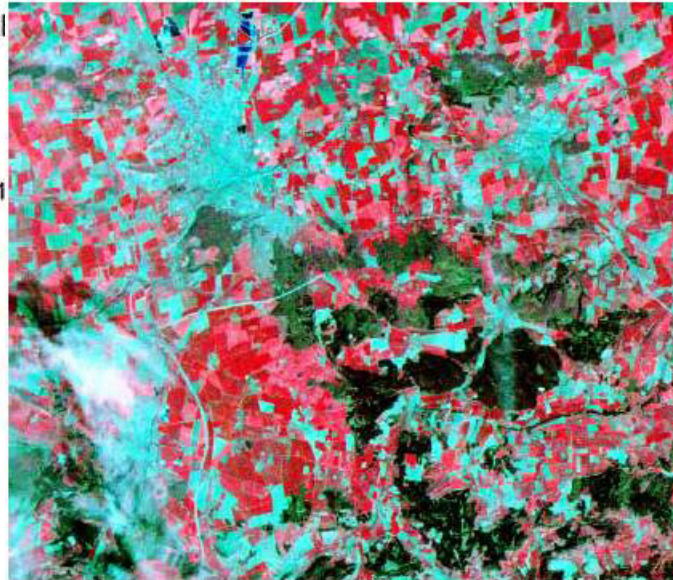
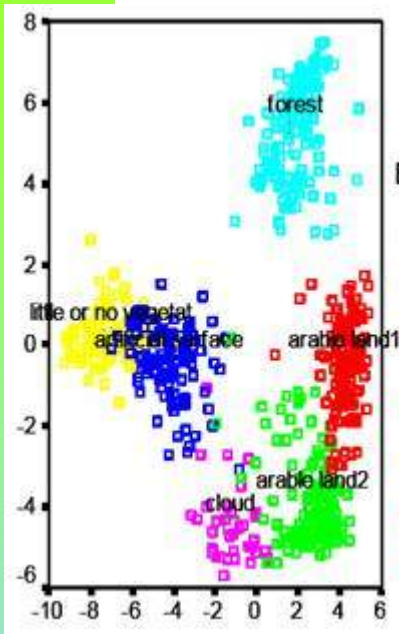


Source: NigeriaSat-1



Regular Monitoring of Lake Chad with NigeriaSat-1 allows rapid & regular water exploration of the region.



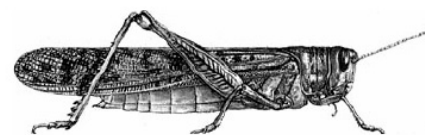


BESTCLASS

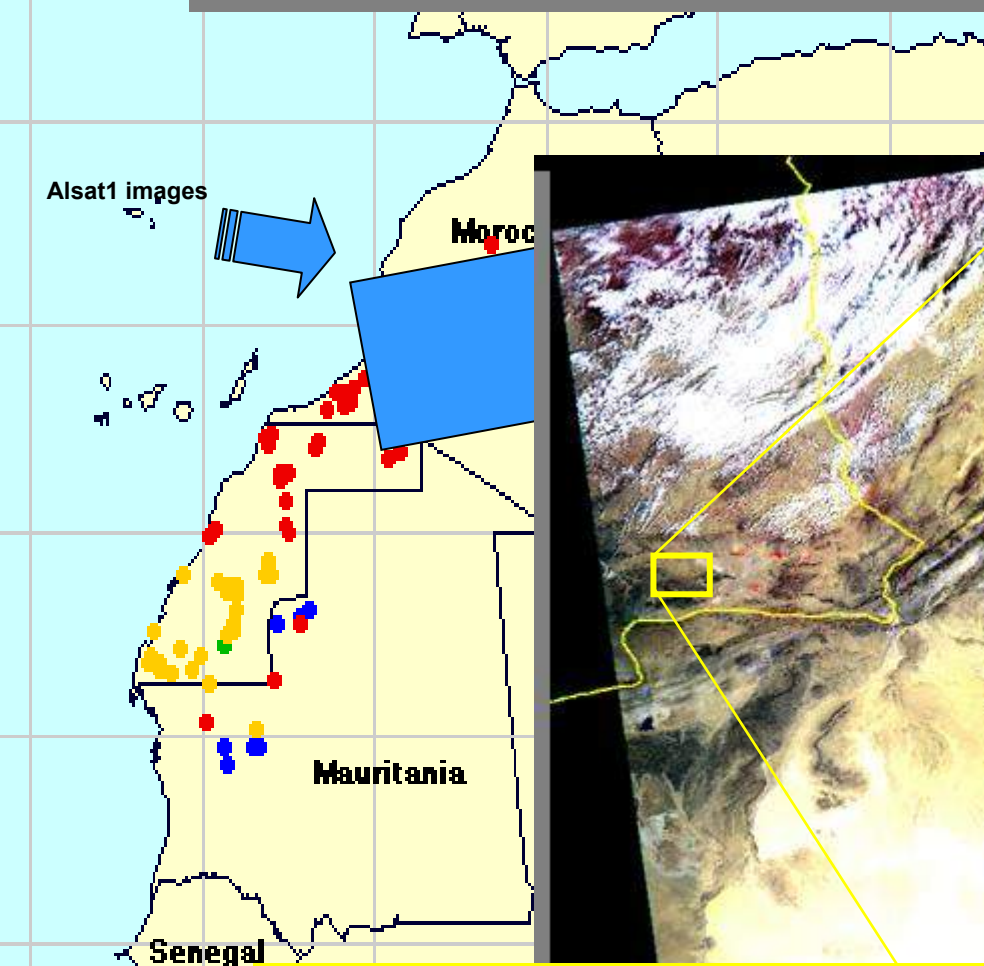
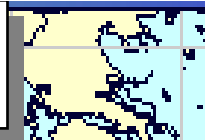
- ☐ Gruppen-Mittelpunkte
- little or no vegetat
- forest
- cloud
- artificial surface
- arable land2
- arable land1

eCognition Segmentation based classification

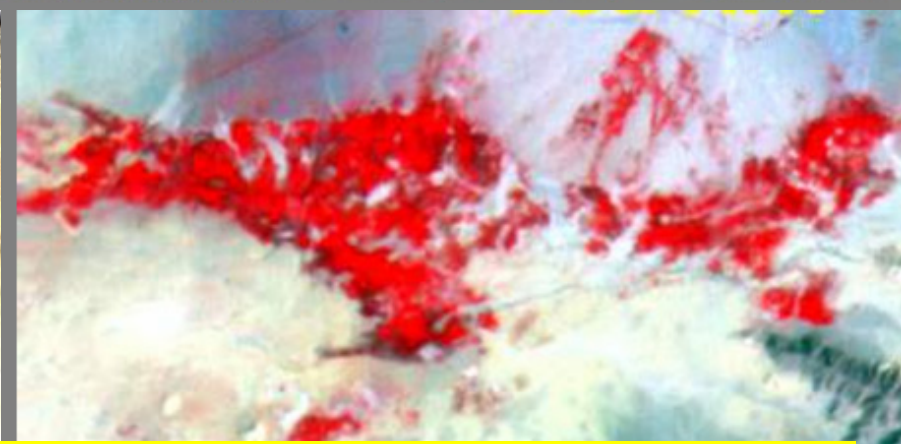
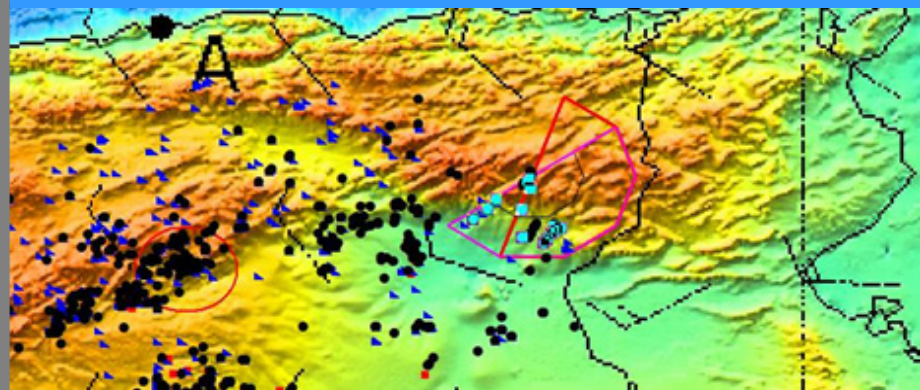
- From 5707 objects 87 training samples
- Only 0.01% of objects needed to reach 'satisfactory classification Results'



Locust Migration Monitoring, Algeria



Combination of meteorology, Satellite data and ground observation predict locust migration routes



Contribution of the Algerian satellite AlSat-1 in the battle against the Desert Locust.

Images from AlSat-1 supported the preventative phase of the fight against the Desert Locust, enabling a regular monitoring of the swarming areas.

 Gregario

Glacial Calving, Greenland Ice Sheet

- **Monitoring Rates of glacial ice release (Calving flux)**
- The Greenland Ice Sheet is melting at rates far quicker than previously realised.
- Predicted global impact: Rising sea levels, Ocean Current instability.



Boreal Forest Fire Mapping, Central Siberia

- Are the Siberian Forests a Carbon Source or Sink?
- Approx. 16,000 forest fires (0.9M hectares) in Russia annually
- Future climate change may alter fire frequency and area
- There is little easily accessible information on Siberian Boreal forest fire dynamics



Image: UK-DMC



Fire Scar, Siberia

Photo: James T. Randerson

Peat Fire Mapping - Central Kalimantan, Indonesia



- **Mapping vegetation burning & peat soil fires in Central Kalimantan**
- Approx. 11 % of Indonesia's total land is peatland (50M Acres 20M Hectares)
- Burning, Logging and Draining has increased fire & flood risk
- In 1997 fires released an estimated 0.87 & 2.57 billion tons of carbon into the atmosphere (13-40% of total annual anthropogenic emissions)

Image: UK-DMC

Fire Monitoring in Portugal



Image: ALSAT-1

Accurate, validated burnt area products for Portugal

- To derive algorithms for mapping burnt areas.
- Determine Severity of burn, pre- and post-burn vegetation characteristics (e.g. biomass)
- Data on the type of fire that has occurred.
- Use data in computing the resultant gas emissions.
- Field validation

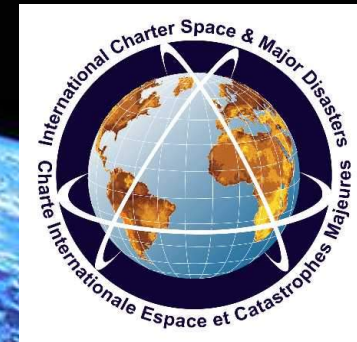


Image: UK-DMC

Investigators: Dr. K. Tansey, University of Leicester
Dr. JM Pereira, JM das Neves Silva & T Santos, Instituto Superior de Agronomia, Lisbon, Portugal.

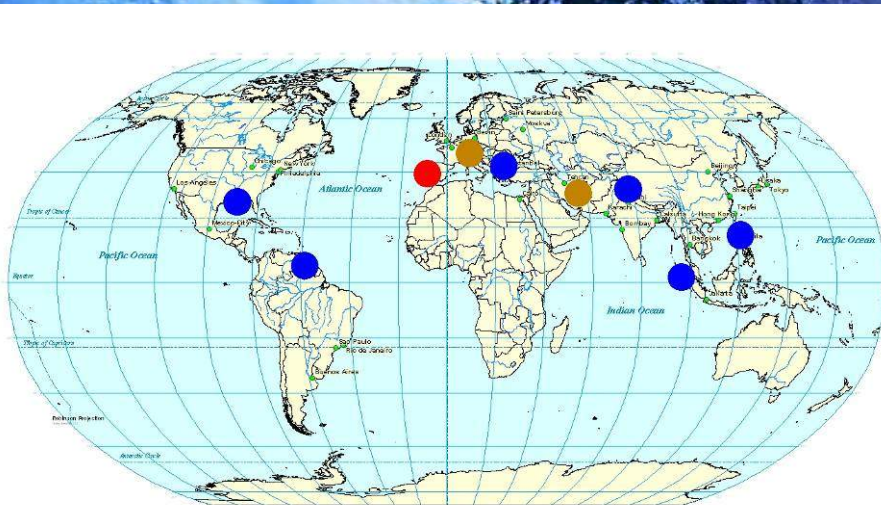
DMC Disaster Response 2005

26/08	Flood	Hurricane Katrina, USA
25/08	Flood Landslide	Switzerland
23/08	Fires	Coimbra, Portugal
27/06	Floods	Sutley River, Himachal Pradesh, India
09/06	Floods	Bulgaria
24/02	Earthquake	Zarand, Kerman, Iran
08/02	Floods	Georgetown, Guyana
27/12	Floods	Indian Ocean, Tsunami
05/12	Floods	Manila, Luzon, Philippines



DMCii Provides: International Charter; "Space & Major Disasters"

- Rapid Response Imagery
- Emergency On Call Officers
- Executive Secretariat Member

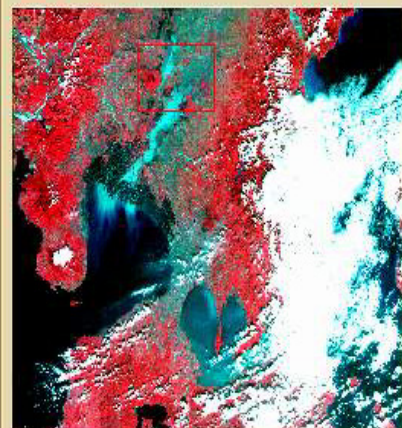
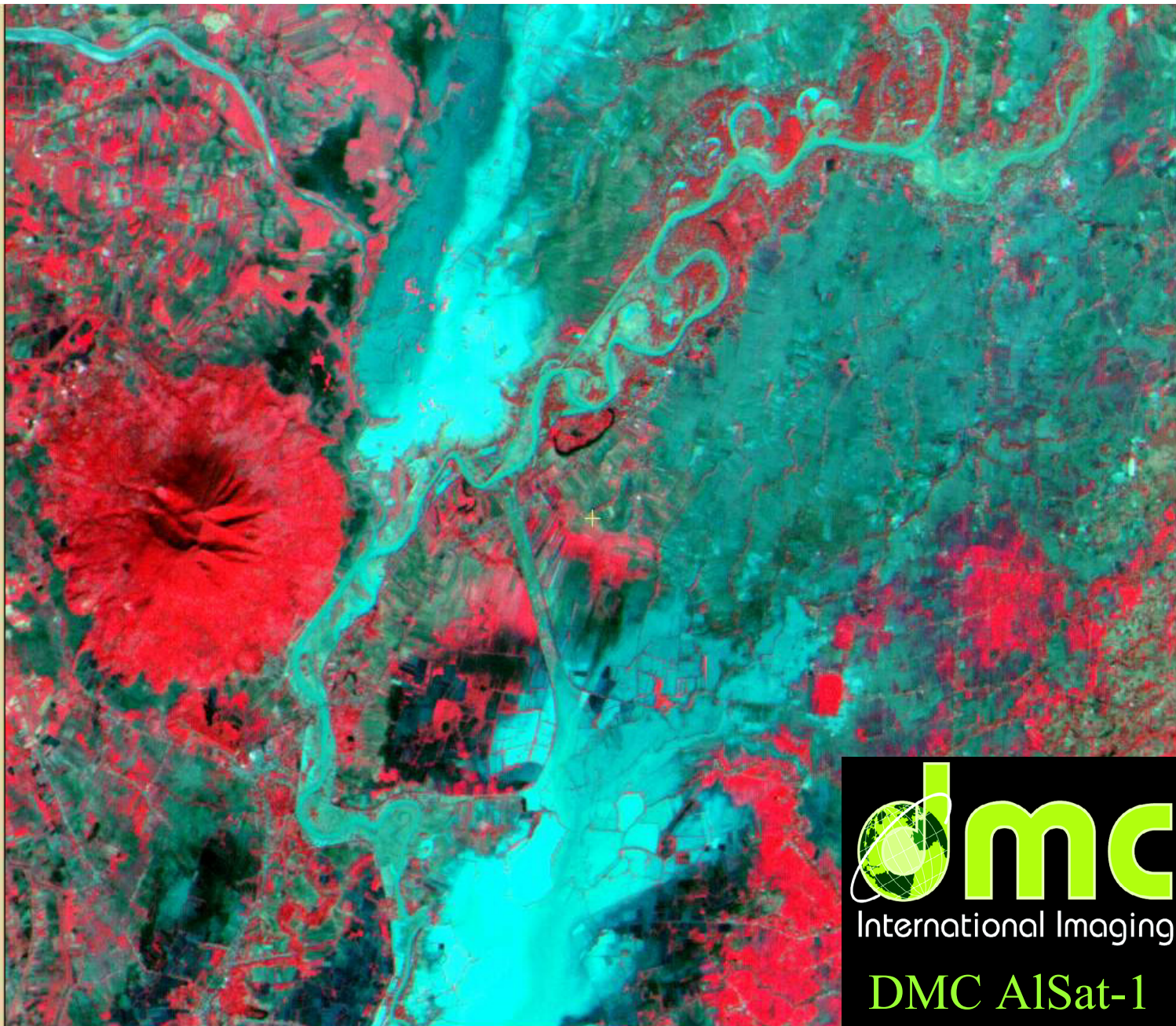


Maps | Files

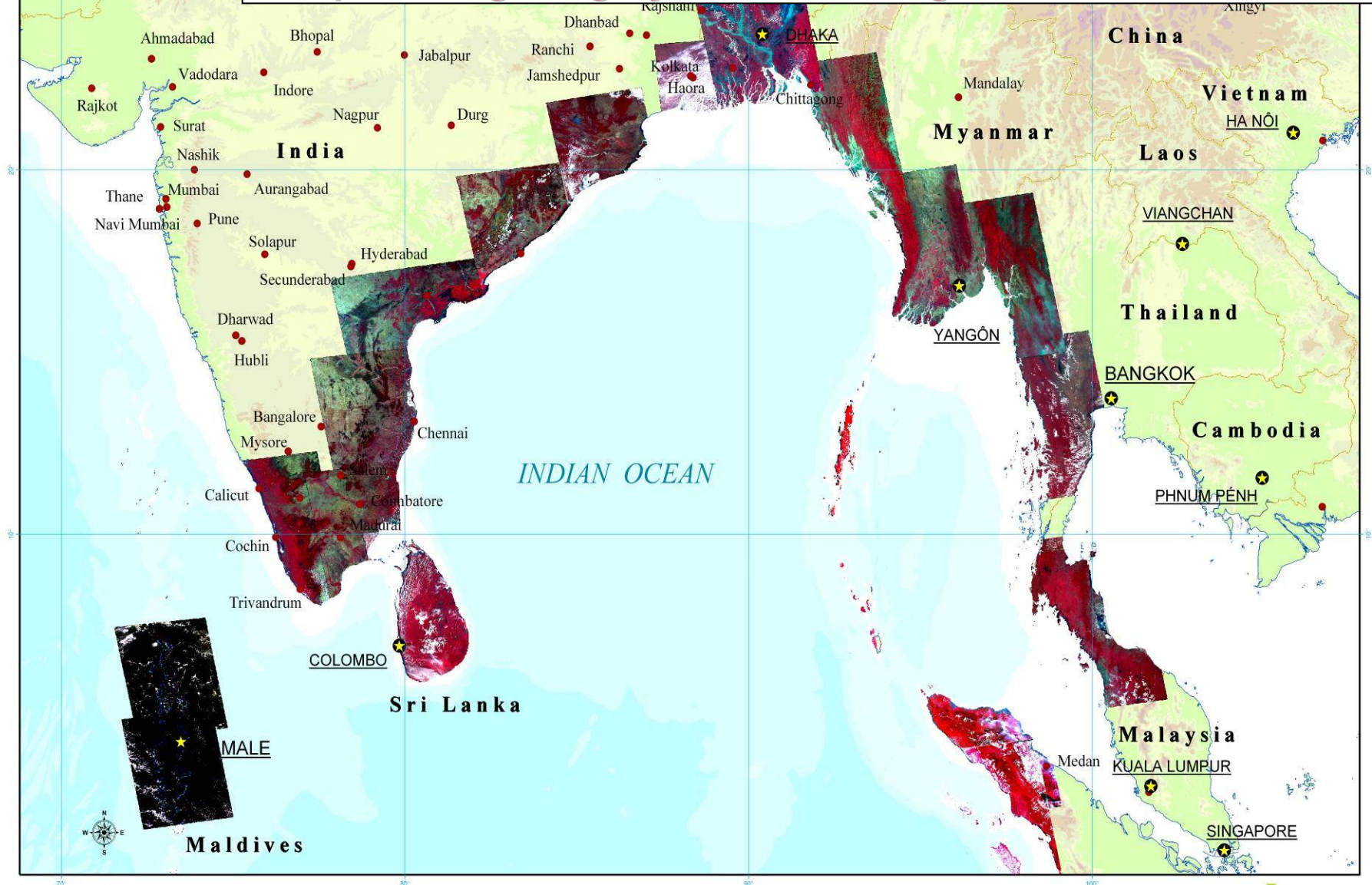


DMC International Imaging
Ltd.
Surrey Space Centre
Guildford
Surrey GU2 7XH
UK

Tel +44 1483 683345
Mail; info@dmcii.com
Website www.dmcii.com



DMC Mapped the Entire Indian Ocean Tsunami Zone providing Imagery Before, During and After the Crisis



Disaster Monitoring Constellation (DMC) - Indian Ocean Tsunami Crisis Coverage

Hurricane Katrina : International Charter Call 104

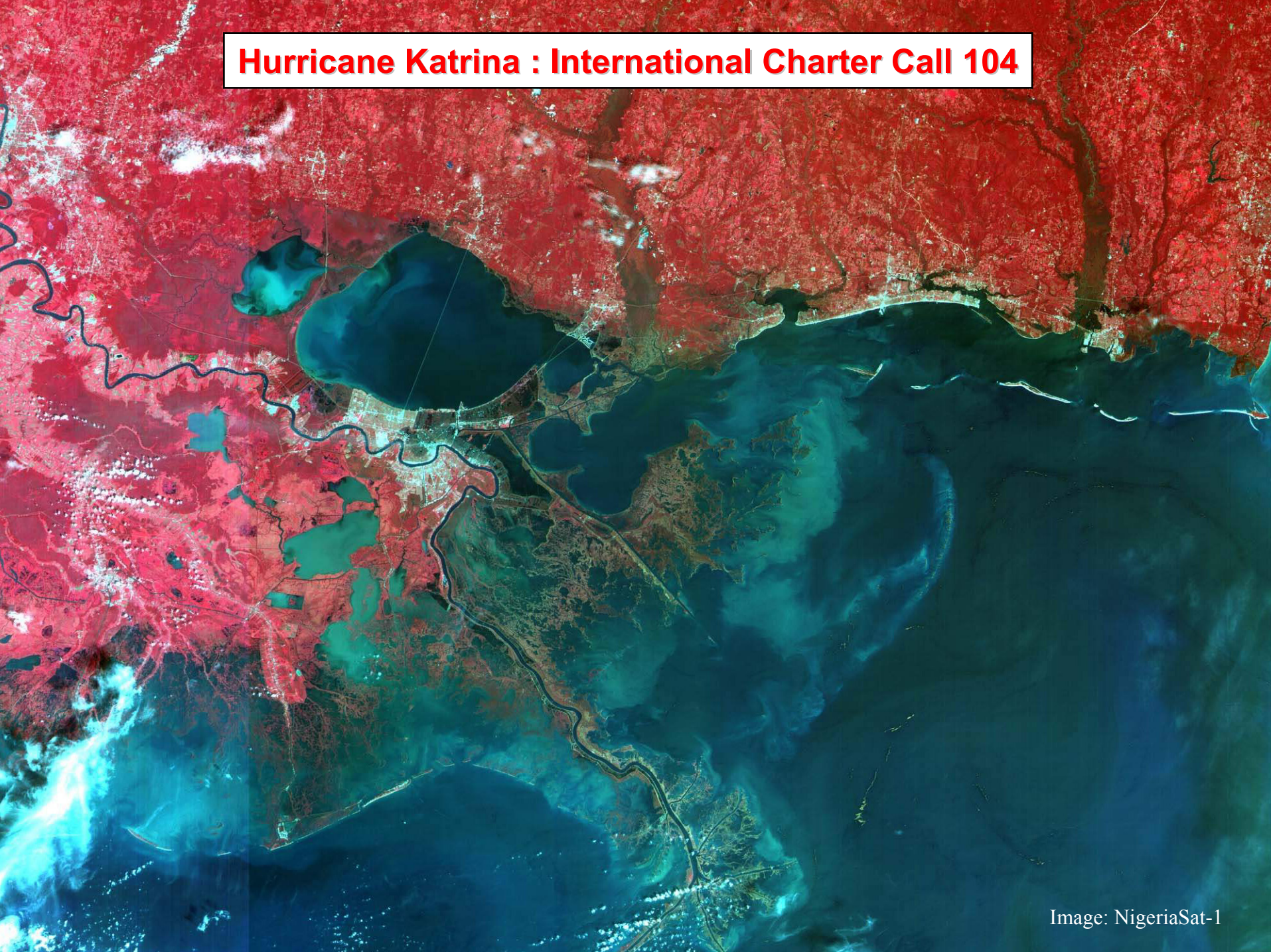


Image: NigeriaSat-1

Hurricane Katrina : International Charter Call 104



Superdome

Lake Ponchartrain

Flooded areas

Smoke plume from wharf

Mississippi River

Image: NigeriaSat-1

Hurricane Katrina : Event Map

Charter Call ID-104 - Product 20

Flood and humidity mapping

02 September 2005

New Orleans - Mobile, USA



Flood impact mapping from the 02 September 2005

- Flooded surfaces
- Very wet areas
- Affected urban zones with flooding in New Orleans
- Reference water bodies (1999-2001)
- Water bodies



Disaster : hurricane, floods
Charter trigger date : 02 September 2005

Thematic layers :
Flood waters, humid areas and affected urban areas
extracted from NigeriaSAT, DMC International data
Reference water extracted from Landsat 7 ETM+ data

Satellite data source :

NigeriaSAT DMC image, natural colors, 32 m
Acquisition date : 02 September 2005
© DMC International Imaging 2005

Landsat 7 ETM+, 28.5 m
Acquisition date : November 1999, August & October 2001
© USGS 1999, 2001 - Maryland

Datum : WGS 84
Projection : UTM Zone 15 N

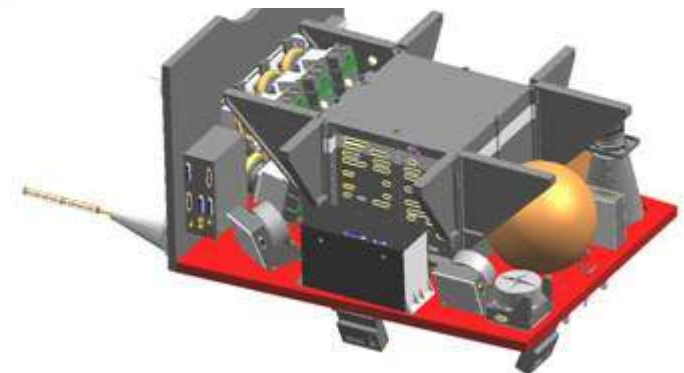
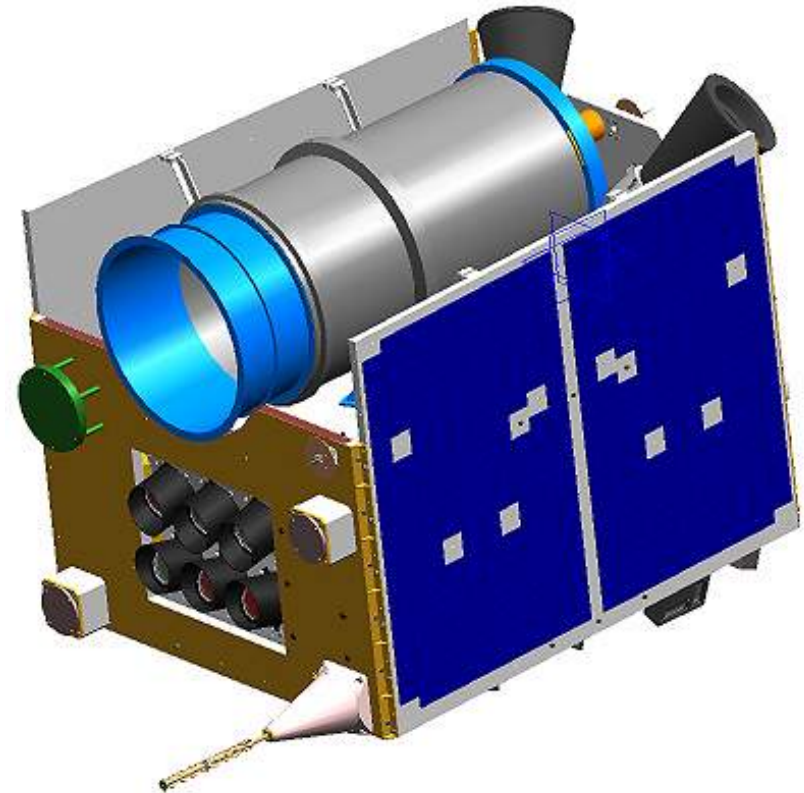
Scale : 1/250 000 for A0 prints

Map created the 09 September 2005 by SERTIT
© SERTIT 2005

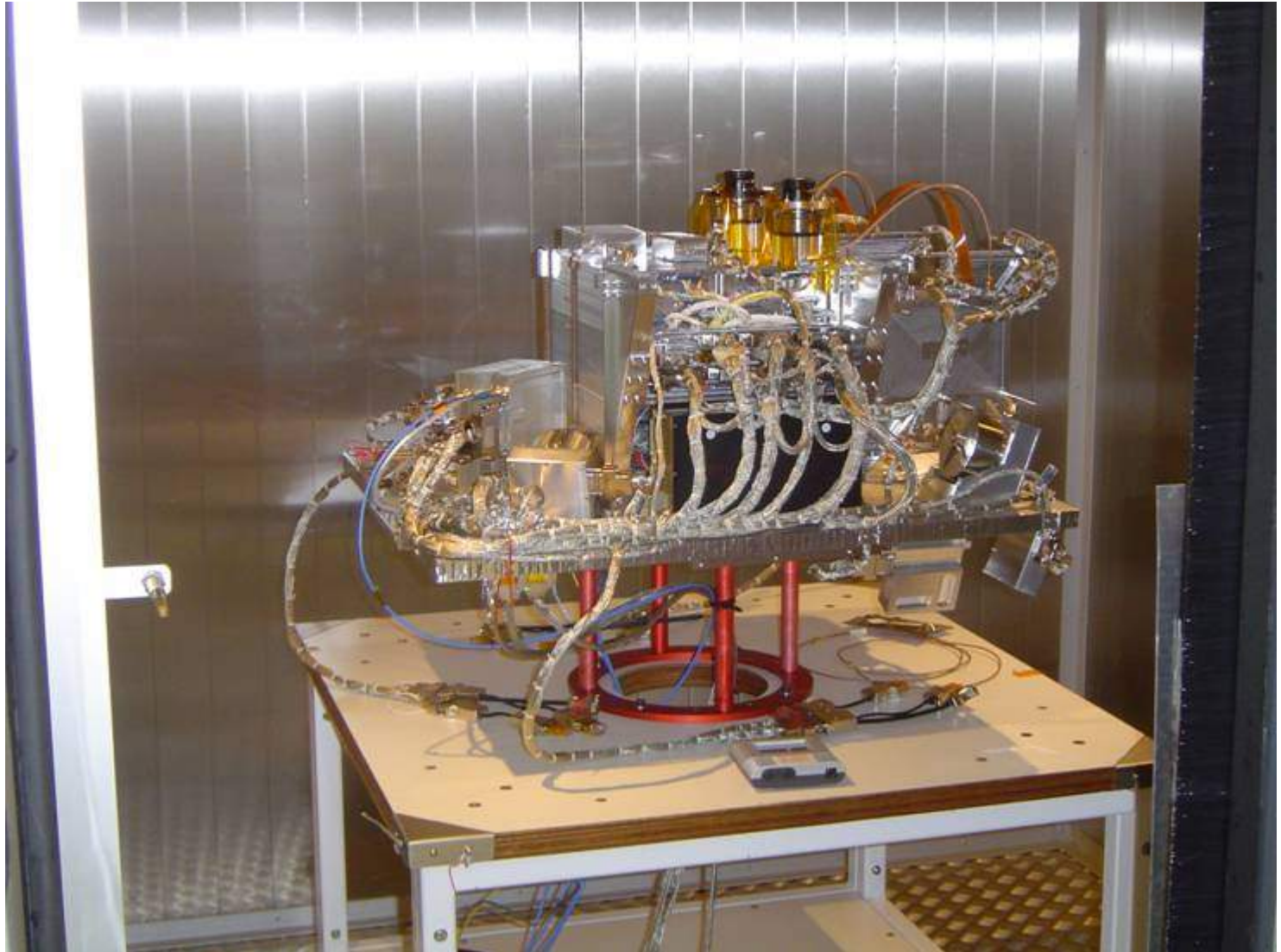
sertit@sertit.u-strasbg.fr
<http://sertit.u-strasbg.fr/>



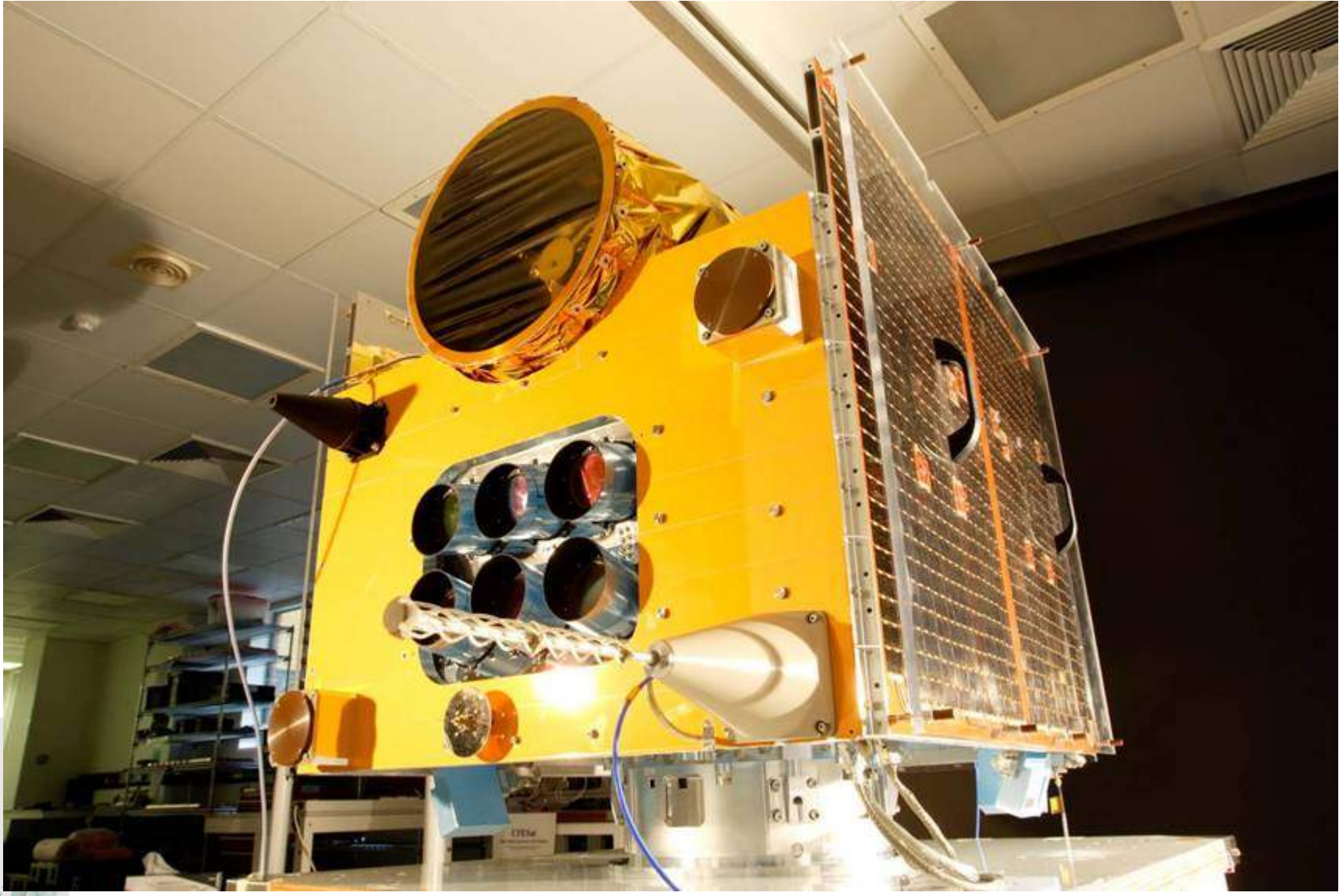
- DMC SLIM6 Imager
 - 32m multi-spectral (3-bands)
 - 600km swath width
 - 8Mbps S-band downlink
 - 1.5Gbytes SSDR
- 4m Pan Imager
 - 4m pan
 - 24km swath width
 - 40Mbps X-band downlink
 - 3 Gbytes SSDR
 - 120 Gbytes harddisk
- ADCS
 - +/- 0.05° pointing knowledge
 - +/- 0.1° pointing control
 - +/- 30° off-pointing capability
- 5-year design life
 - With orbit station keeping



- Launched on 27 October 2005



- Launched on 27 October 2005



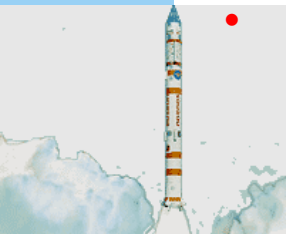
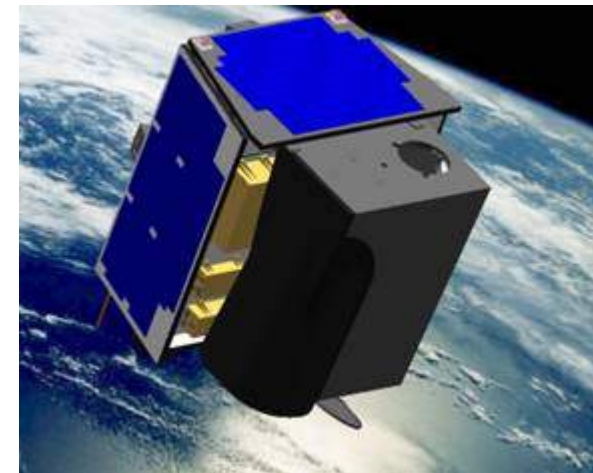
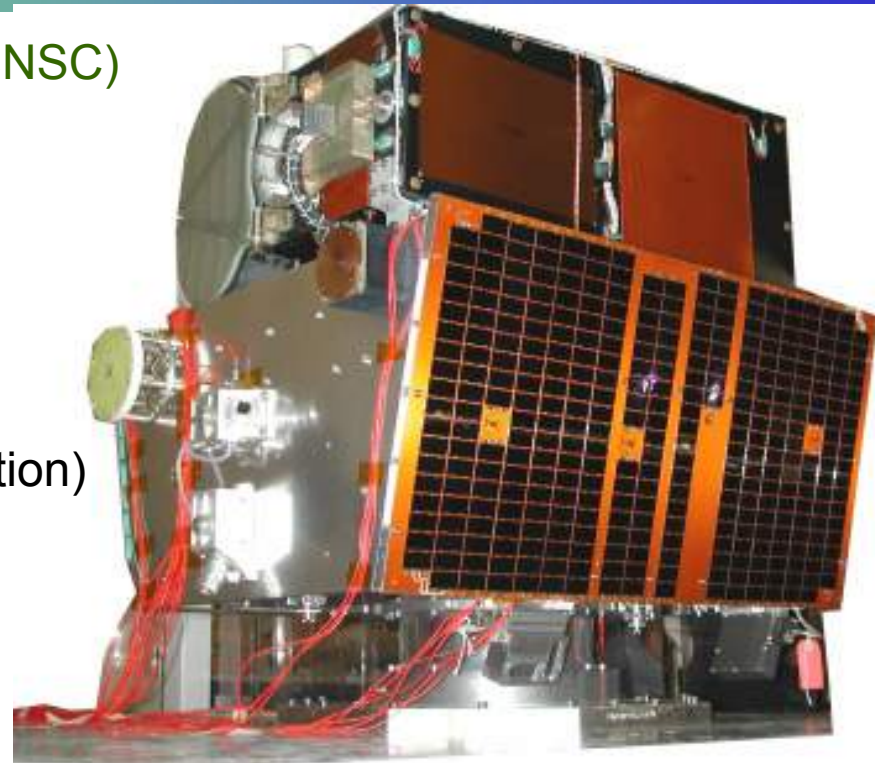
DMC+4 : Cairo Airport



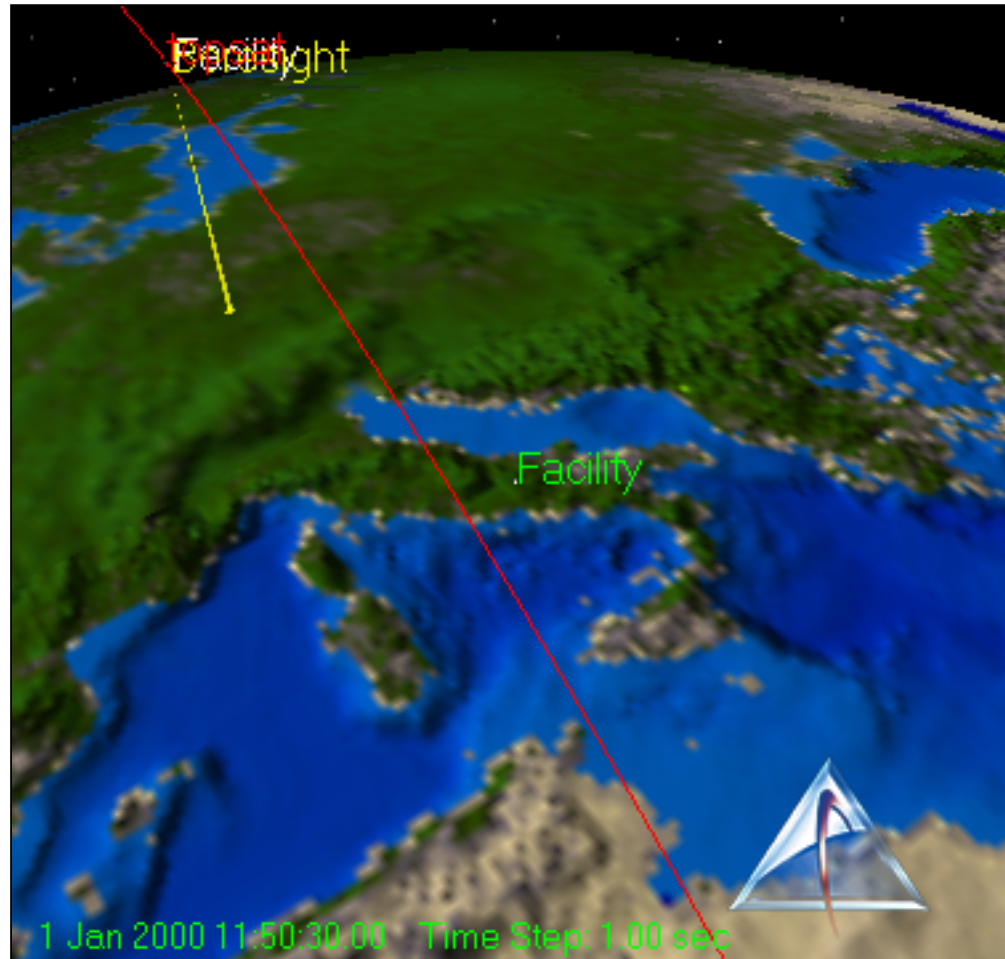
- Customer: QinetiQ (UK MoD and BNSC)
- 2.5 m resolution panchromatic, 5m multispectral imaging
- Enhanced microsatellite: 120 kg
- High performance ADCS
 - Roll/Pitch (time domain integration)
 - Rapid slewing
- State- of-the-art ratio of optical resolution to satellite mass

Launched October 2005 with DMC+4

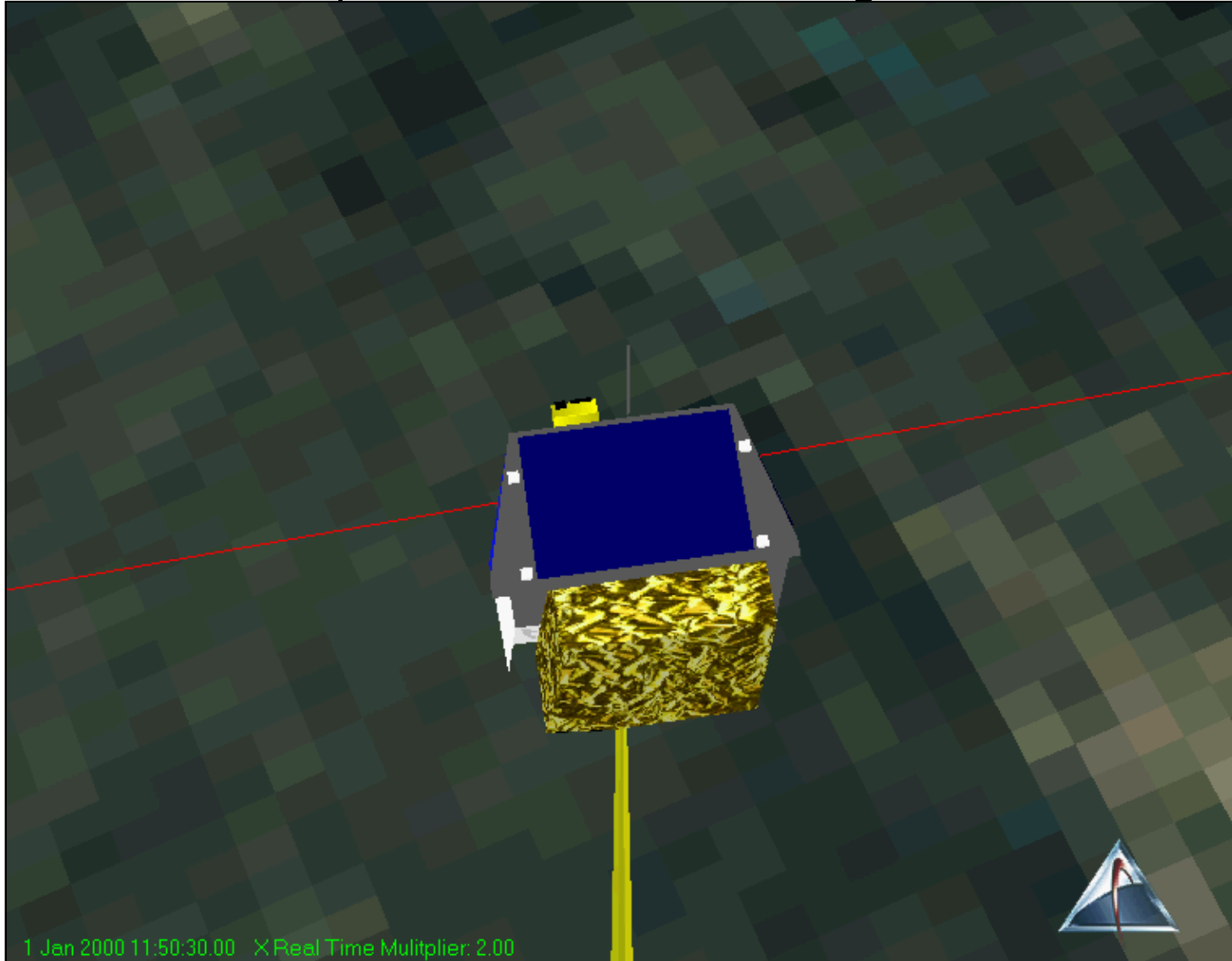
- Cosmos LV from Plesetsk
- In commissioning
- First images November 2005



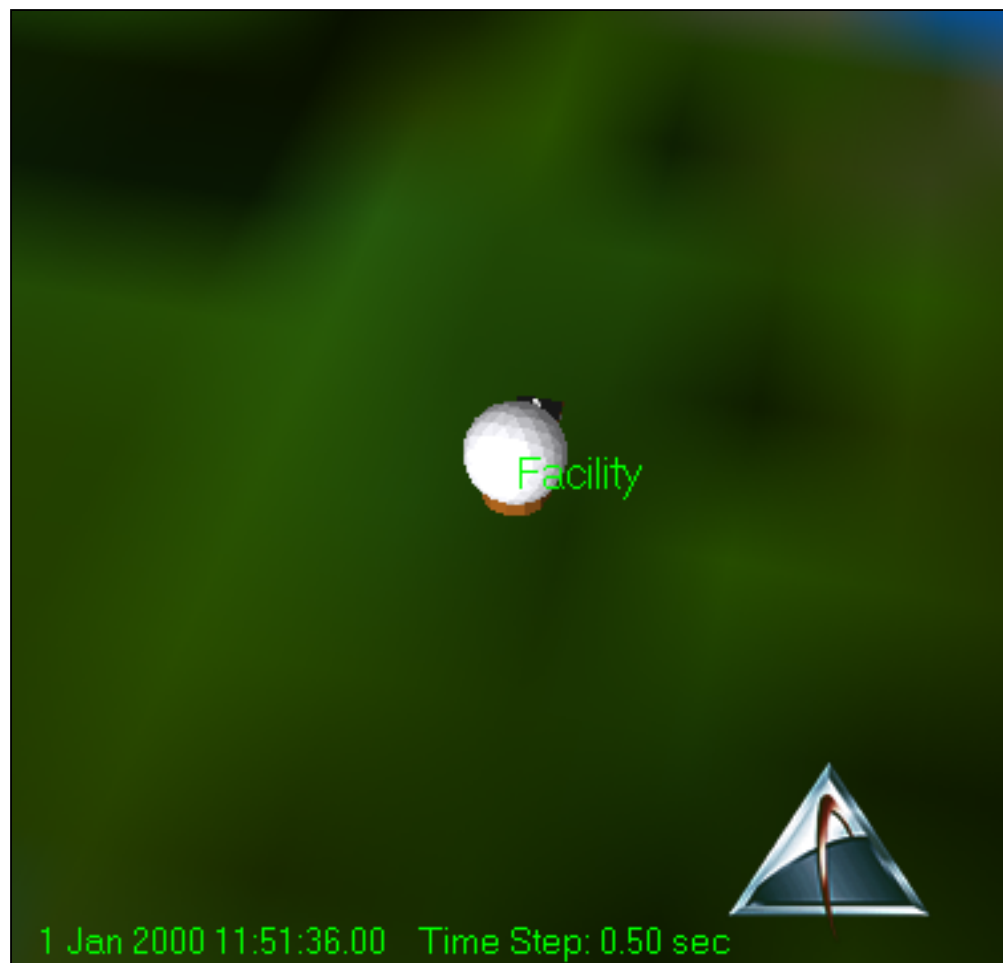
- Operational Concept – Time Domain Integration



- Operational Concept – Time Domain Integration



- Operational Concept – Time Domain Integration



Topsat

